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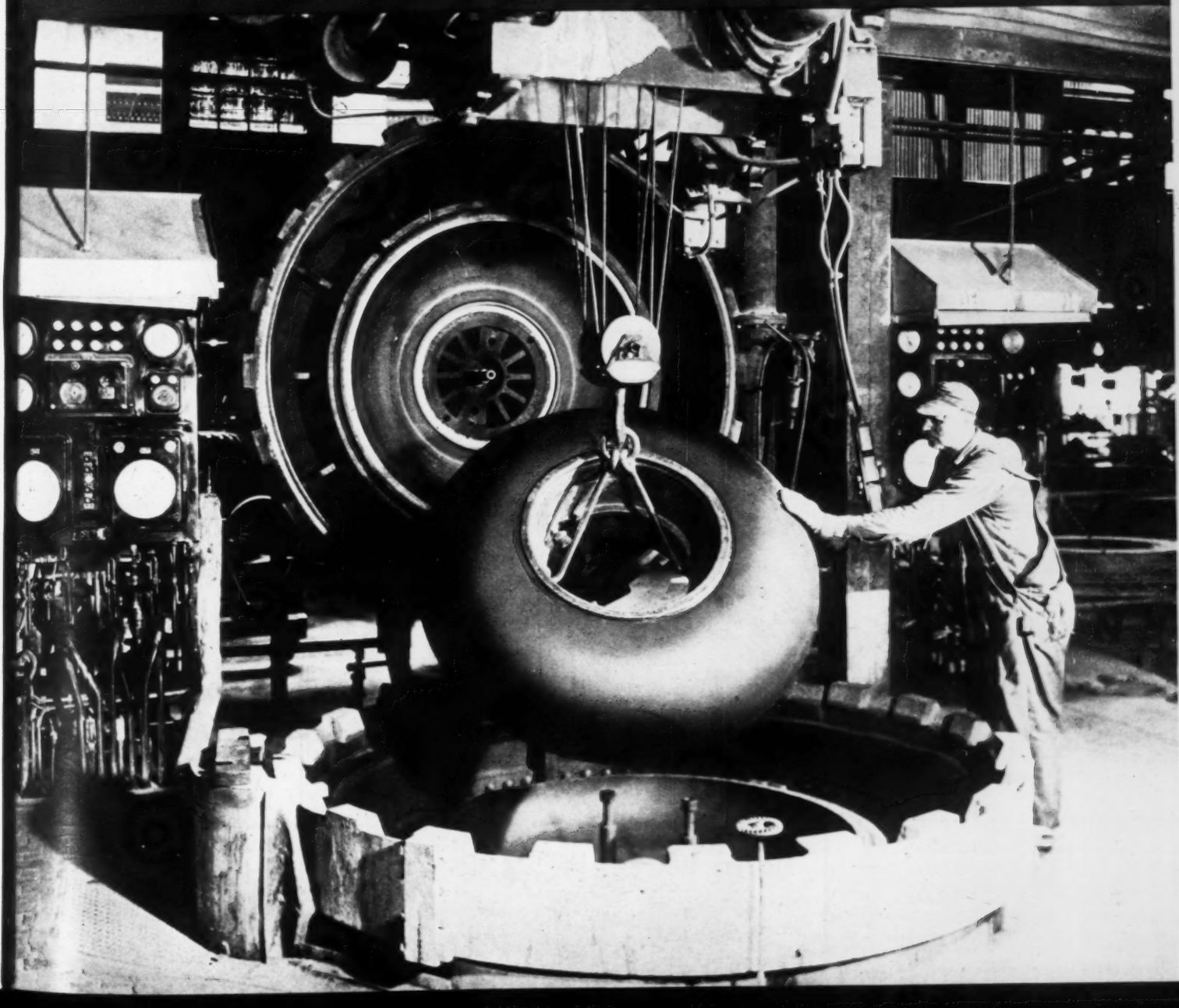

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Instruments THE MAGAZINE OF Measurement and Control

M. F. BEHAR, Editor

Instrumentation's Unity in Peace and War

PRINTING a "story" of "the story behind the front cover" is not uncommon, but this is the first time we ordered a photograph of a subject after seeing a small print of it, for illustrating the theme of an editorial already in mind. Now, please stop reading this and examine the cover photo carefully. . . . Even if you are not a specialist in process control boards, or in the manufacture of rubber tires, you will have noticed that the control boards are old ones, while the controlled vulcanizer at the Goodrich plant *must* be a new one—for the tire is recognizable as the kind for our bombers. "Instrumentation's Unity" has been the title of discourses which have appeared on this page in the last eight or nine years. This time, in signalizing the inauguration of the Aviation Instruments Department (pages 207-218) it may not be amiss to point out that all aviation manufacturing industries, as well as civilian aviation and military and naval aviation, owe an enormous debt to non-aviation instrumentation; and that many branches of science and industry are beginning to be indebted to that precocious youngster Aviation Instrumentation.

In a larger sense, Instrumentation owes an enormous debt to all sciences. Every industrial gage, meter, testing machine and control system was brought to its present state of excellent performance by reason of centuries of work in the pure sciences. Certainly, Galileo did not lay the foundations of thermometry in 1591 with modern industries in mind, but the measurement and automatic control of industrial temperatures would not be possible without the heritage left by him, by Rey, Newton, Wedgewood, Carnot, Kelvin, Stefan, Boltzmann, Wien and Planck (to stop at the year 1900).

And "industrial" instrumentation has been repaying its debt! Go to any great laboratory of pure research and you will see huge pieces of apparatus equipped with control boards sired by science but born and bred in industry. (By the way, is there any scientific instrument as "wonderful" in its way as a self-balancing potentiometer or bridge type recorder-controller? The basic principles had been laid down by pure science but when Dr. Morris Leeds in 1912 designed and built the first successful one, he did it for the metallurgical industries.)

Another lesson which the Goodrich photograph conveys at a glance is the important rôle of Instrumentation in conversion. As was declared again and again on this page during the eight years before Pearl Harbor—while this page was preaching preparedness against gangster nations—industrial instruments, from simple gages to elaborate automatic-inspection or control systems, are not mines to be dug, factories to be built, pipe-lines to be laid: they are readily-available products which can achieve miracles when our nation has to fight for its life against enemies who had for years enlisted science and technology for total war.

It is said that the "shopping list" of the Army Ordnance Department alone includes more than 200,000 separate items. Add the Army Quartermaster and Engineers shopping lists and those of the Sea Forces and Air Forces: the task of converting from peace to war is such as to deserve the words "tremendous" and "stupendous." But I dare say that 95% of the measurement and control devices which accelerate the production of all items on all these shopping lists have been put to their new uses without any alterations. Only a few (such as automatic-gaging and automatic-inspection set-ups) have required re-design and development for specific application to war items.

But even where instruments had to be re-designed, the fundamental principles of their application did not have to be changed! Again the lesson emerges that Instrumentation is more than instruments—that it is a science in its own right—a science which is indebted to all other sciences but which in turn enriches them all.

Now for a word to our new subscribers. (To address them specifically is justified because of their number.) Most of you are interested in your war-time jobs, but may not be certain of your occupations in the era of industrial reconstruction when Fascism will have been wiped off the face of the earth. It is suggested that you extend your interest in instruments—not only those which you actually work with, but related ones. Go from one type to another; then from one class to another; then keep on extending your investigations, always with a healthy curiosity. The rewards will be enormously greater than the effort—if such a pleasurable quest can be called an "effort." Many prominent *Instruments* subscribers, in the technical branches of the Army and Navy as well as in the industrial world, can testify that they owe their promotions largely to their study of instrument engineering principles. Most of them have jobs with titles that do not even suggest instrument work. However, it was their healthy curiosity about instruments which led them to discover that they should specialize in some particular branch of production or inspection—some particular phase of electricity or electronics or mechanics or chemistry.

Of deeper significance, in this day when we are fighting to save humanity from a thousand years of darkness and savagery, is the fundamental doctrine of Instrumentation that in order to control any condition you must first measure it. A prime purpose of all those who use measurement and control devices in the War Effort is to conquer variables. The gunnery officer on a battleship who relies on a synchro-tie system; and the rubber technologist who relies on automatic process-program controllers—these and many others are striving to conquer variables. Instrumentation declares that in order to conquer variables you must reduce them to measurables. You must isolate each factor, install an appropriate measuring element, then select a governing means commanded by the measuring element. This doctrine is Instrumentation's contribution to social sciences. Instrumenticians who cherish this doctrine could do a better job of "regulating" this sad world than has been done in the last 7000 years by each successive wave of "regulators." Instrumentation principles applied to mankind could achieve unity-with-diversity, as we see in any thoroughly instrumentized processing plant . . . but that's something to keep in mind for the future, because our present job is to apply Instrumentation directly and practically to the specific task of exterminating Nazism and Nipponism. —MFB

Instrument men in the vicinity of Baltimore who are interested in forming a local Instrumentation Group should send their name and address, as well as company and position to C. A. Baker, E. I. duPont deNemours & Co., Inc., Curtis Bay, Baltimore, Md.

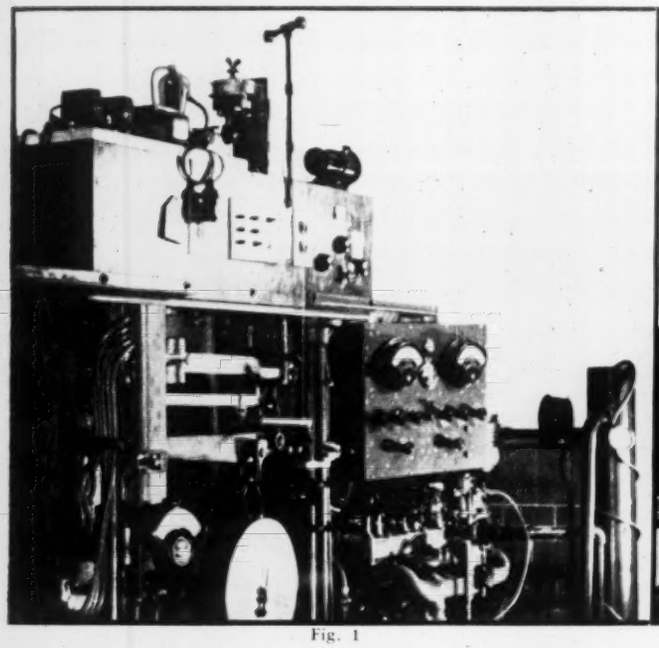


Fig. 1

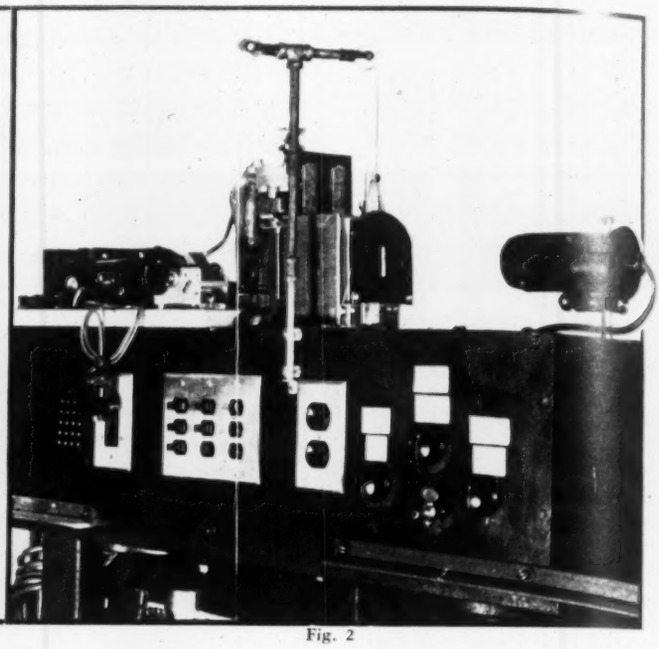


Fig. 2

A Photocell-controlled Dynamometer Loader

By R. R. PROCTOR

Instrumentation Engineer, The Pure Oil Co., Mechanical Laboratory, Chicago, Ill.

IN the past, a good percentage of work done in connection with petroleum research has been done on the road in test cars. However, many laboratories are so located that climatic conditions prevent actual road testing for a part or most of the time each year. It has long been felt desirable to be able to obtain at least a part of the data necessary in motor fuel research in the laboratory, where tests could be run under controlled conditions at any time, day or night, independent of weather or road conditions, etc.

With this in mind, an attempt was made to "devise a device" which would automatically control a dynamometer in such a manner that road loading of an automotive engine under acceleration could be duplicated in the laboratory. After several months of work and many discarded "gadgets" and theories, the apparatus as shown in Figs. 1 and 2, crudely constructed though it appears, finally was developed to the point where it gave the desired results, i.e., it loaded the engine exactly as it was loaded in a car on the road, under full throttle acceleration, which is the basis for most of our fuel rating work. Fig. 3 shows schematically the arrangement of the original device. The principle of operation in the original design is as follows: The dynamometer (of the eddy current type, which draws little field current) is supplied by an FG-95 thyratron, the grid of which is controlled through a phase shifting network by a photocell. The amount of light reaching the cell is controlled by a pair of apertures, one fixed, the other moved by the motion of the scale beam on the dynamometer.

This type of dynamometer is of the eddy current type (Dynamatic). It has a characteristic similar to the speed-time curve of an automobile at low speeds, up to about fifteen miles per hour. Thus at low speeds, no correction is needed in loading. The scale beam is down, the masks wide open and the light is adjusted to give the loading necessary (as observed on the dial scale) at 10 m.p.h. As the throttle is opened, the loading follows the dynamometer curve up to 15 m.p.h. when the scale beam begins to rise, actuating the masks so as to reduce the amount of light reaching the photocell. From 15 to 65 m.p.h. this constant load is maintained. If it increases slightly, the upward motion of the scale beam cuts off some of the light from the cell, lightening the load and allowing the scale beam to return to mid-position, and vice versa. From 65 to 70 m.p.h. the load curve then follows the torque characteristic of the engine; in other words, acceleration begins to decrease even with constant load. Thus the speed-time curve of a car accelerating from 10 to 70 m.p.h. at full throttle is duplicated on the dynamometer, and data obtained by the use of this set-up show remarkable correlation with actual road test data.

Fig. 4 is a circuit diagram of the loading sup

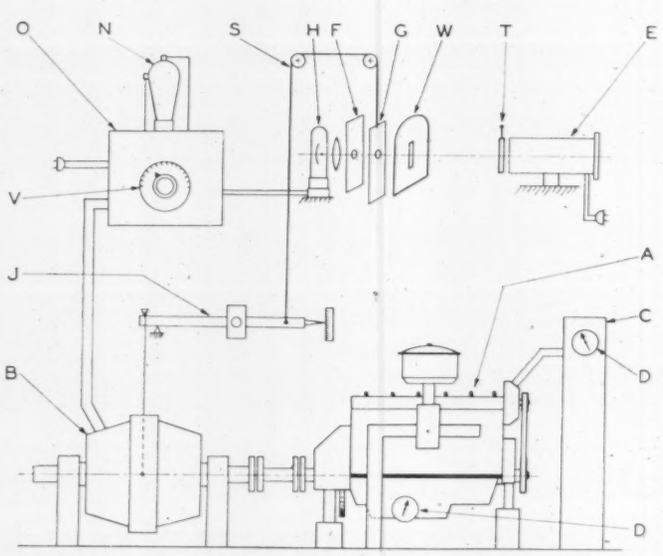


Fig. 3

A—Engine
B—400-HP Dynamatic Dynamometer
C—Engine cooling tower
D—Thermometer
E—Light source
F—Fixed aperture (scanning slit)
G—Movable aperture (or mask)
H—Cetron CE-1 photocell
J—Scale beam
N—G.E. FG-95 thyratron
O—Filter
S—Linkage (on original set-up)
T—Iris
V—Sensitivity control
W—Stray light shield

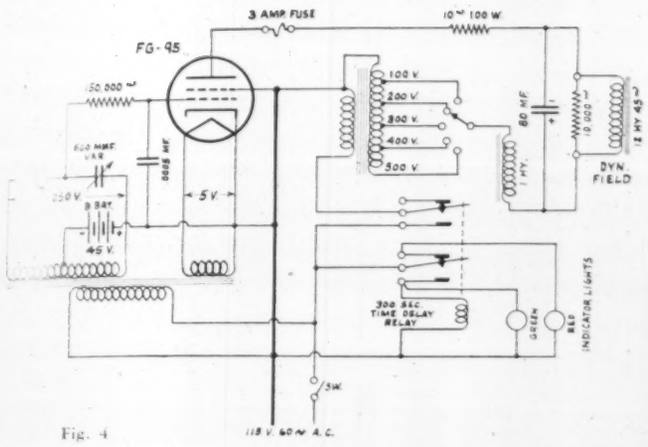


Fig. 4

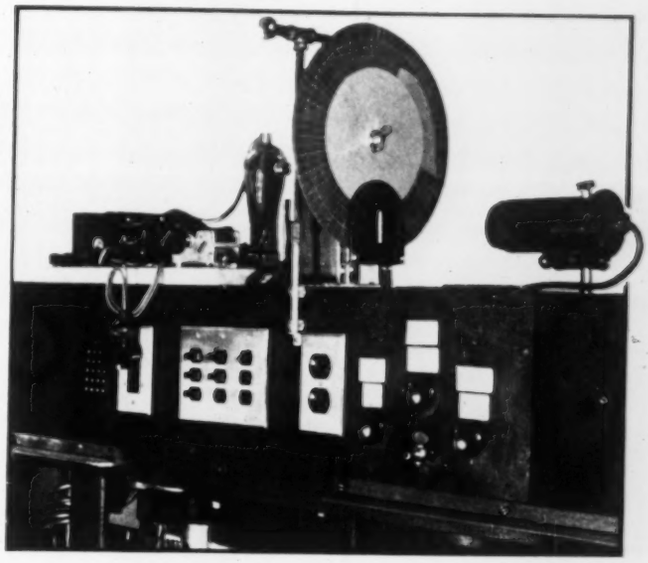


Fig. 5

ply, which, with only minor variations, is the same as is being used at present in our more refined apparatus. The loader and light source are supplied from house current through a constant voltage transformer.

Other types of curves have been duplicated by employing a circular mask, the desired curve being plotted on polar coördinate paper (Fig. 5), cut out as a solid, and placed between transparent disks which turn at $\frac{1}{2}$ r.p.m. between closely-spaced scanning slit and photocell. Some part-throttle work has also been done using the circular mask and a vacuum governor.

Figs. 6 and 7 are two views of the control in finished form as it is now being used. The mask is now attached directly to the tare arm of a flash scale and moves past a $1\frac{1}{4}" \times \frac{1}{16}"$ scanning slit in front of the photocell.

The two fan-type instruments and associated controls seen in Figs. 1, 2, 6 and 7 comprise an electronic tachometer and spark advance indicator. The light source is a 110-volt microscope light with self-contained lens system and iris diaphragm. Adjustments are provided for all set-up changes desired. The sensitivity control (the variable capacitor in the grid network) is set to prevent hunting. The light is controlled by a rheostat to set maximum load conditions. The shape of the mask is adjustable to control minimum loading desired, and its length of opening adjustable to provide the range between minimum and maximum load for each different engine that is used on the dynamometer stands. Almost any type of road curve obtainable with any automobile can be duplicated on the dynamometer by the proper adjustment of these variables. (By "road curve" is meant speed-load curve, acceleration-load curve, speed-time curve, etc., as briefly explained above.) It is agreed that this type of control will not entirely replace road testing as we cannot duplicate in the laboratory all types of weather under which we want to obtain data, nor can we install a new engine and know its road characteristic without first running it on the road in a chassis for which it was designed. However, it has proven a very useful adjunct to road testing, and much road and test car work has been eliminated by the use of this control. It is still undergoing experimentation and improvement and, in conjunction with some additional apparatus developed to control barometric and humidity conditions at the engine carburetor, its field of usefulness is constantly being enlarged. This is increasingly valuable to us since wartime measures have gradually restricted the use of test cars.

* * *

Thanks are extended to the Society of Automotive Engineers, from whom permission was obtained to abstract and reprint from the paper "A Proposed Method for Duplicating Road Octane on Multi-Cylinder Engines in the Laboratory" by J. A. Moller, H. L. Moir, F. C. Minor and R. R. Proctor, presented at the S.A.E. Convention at White Sulphur Springs, June 6, 1941; and the Pure Oil Company and the other authors of the original S.A.E. paper.

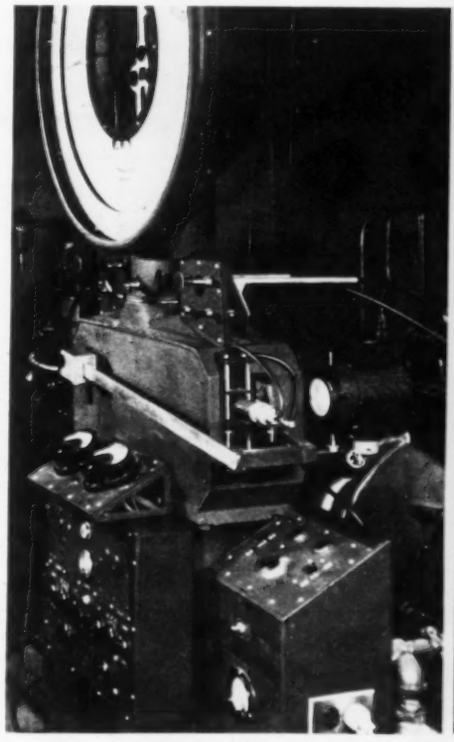


Fig. 6

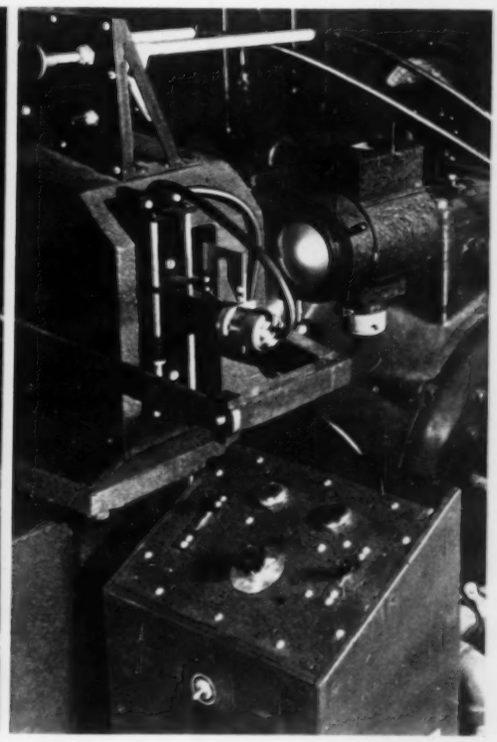


Fig. 7

Direct Determination of Coefficients for Flow Meters

By R. C. BINDER

Assoc. Prof. of Mech. Eng. and Fluid Mechanics, School of Mech. Eng., Purdue Univ., Lafayette, Ind.

THERE are advantages in expressing flow coefficients as a function of Reynolds' number $R = \rho V d/\mu$, where V is velocity, d is some characteristic length, ρ is density, and μ is absolute viscosity. Reynolds' number is a pertinent and convenient parameter for correlating data for similar flow conditions with the same and different fluids. Any consistent set of units can be employed in using the dimensionless ratio R. Flow factors for orifice, flow nozzle, and Venturi meters are expressed as a function of R. It is common practice to correlate pipe friction, lift, and drag coefficients with R.

The discharge coefficient for a fluid meter can be determined if $\rho V d/\mu$ is known. In many practical cases, however, the main problem is to determine the rate of discharge or the velocity. It is sometimes stated that a trial and error method of computation is necessary. The suggested procedure is to assume first a velocity (or R), next determine the corresponding flow coefficient, and then check, or repeat until the calculated velocity (or R) agrees with the assumed value.

The following discussion shows that a direct method of flow coefficient determination is possible; that a trial-and-error method of computation is not necessary.

As an illustration, consider an orifice meter with inlet pipe diameter d_1, orifice diameter d_2, and orifice area A_2. Let V_2 be the actual average velocity in the orifice opening. Application of the energy equation and the continuity equation gives the familiar expression

$$Q = KA_2\sqrt{2gh}$$

$$\text{or } V_2 = K\sqrt{2gh} \qquad \ldots\ldots\ldots (1)$$

where Q is the rate of discharge, h is the measured or effective differential head, and K is a flow coefficient which includes the velocity of approach factor. K is frequently listed as a function of $V_2\rho d_2/\mu$.

Since K is a function of V_2, and V_2 is a function of h, K might be given as a function of h; there is a problem regarding the most effective and general manner of expressing this relation. R can be written

$$R = \frac{V_2\rho d_2}{\mu} = \frac{\rho d_2 K}{\mu}\sqrt{2gh}$$

$$\text{or } \frac{R}{K} = \frac{\rho d_2\sqrt{2gh}}{\mu} \qquad \ldots\ldots\ldots (2)$$

The dimensionless ratio R/K will be called a T number.

It is to be noted that d_2, h, ρ and μ are quantities which are directly measured or established before making a discharge calculation. If suitable T lines are available on a diagram of K vs. R, then the coefficient K can be determined *directly* once T is established.

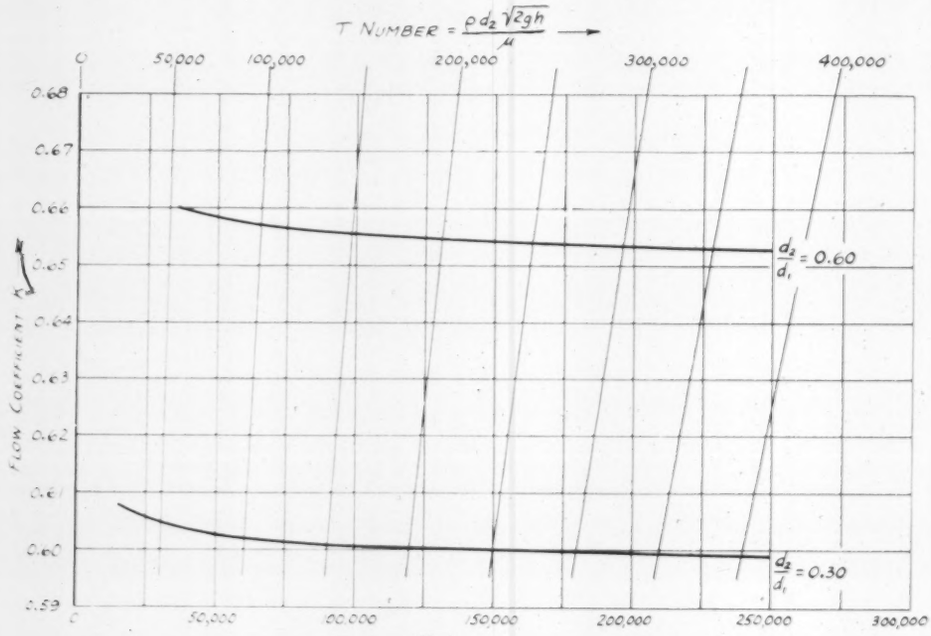


Fig. 1. Example of Chart for Direct Determination of Flow Coefficient. Data for orifice meters in 6" pipe, vena contracta taps.

Fig. 1* shows an example. The procedure is to calculate first the ratio $\frac{\rho d_2\sqrt{2gh}}{\mu}$, follow along the T line to the curve applying, and then read K or R directly. The procedure requires no trial-and-error computation—no assumptions are necessary. T lines can be easily added to a diagram. The equation of a constant T line is $R =$ constant K. This is the equation of a straight line, and only requires two points for plotting.

The same general method can be applied to plots of K vs. R for flow nozzles and Venturi meters. The good unifying features of a K vs. R diagram can be supplemented with T lines—to permit a direct determination of coefficients for flow meters.

*Data taken from "Fluid Meters, Their Theory and Application," A.S.M.E., 1937.

Measurement and Control of Flow Rate May Be Advanced by Discovery of Liquid Flow Types

In 1883 Osborne Reynolds demonstrated that there are two distinct kinds of liquid flow. Most *Instruments* readers remember the experiment that bears his name—the experiment where the red-dye filament stays well-defined while the flow is *streamline* or *viscous* and spreads out all over when the flow is *turbulent*. A few years later Reynolds published his studies on the *critical* flow range, including "sinuous" flow, "upper" and "lower" critical velocities, etc., and made his greatest single contribution, that there is a dimensionless ratio or criterion whereby all flow characters and rates of all fluids may be graded numerically. This is the Reynolds Number. It was first brought to world-wide notice by Stanton's and Pannell's work on similitude and wall-friction soon after the turn of the century. Then it was modified, made practical and successfully applied to flow *measurement* by a fourth Englishman, John L. Hodgson. In fact, although 99.99% of flow meter users think that "*R*" was used in meter work by Reynolds in the eighties, the results of the first tests ever made to apply what is now called the Reynolds Number to orifice flows were published[1] by Hodgson in 1917. Since then, leadership in this field was shared among several nations and from time to time passed to the United States by reason of the A.S.M.E. Fluid Meter Research Committee's work under R. J. S. Pigott. In the last three or four years, chemical engineers here and abroad have been making noteworthy contributions, as have cytologists, hematologists, geologists and other new groups; but, up to a few days ago, most of us in America were inclined to believe that the glorious days of "discoveries" had definitely given way to an era of mere "refinements."

A few days ago, thanks to British and American naval escorts, copies of the May 2 issue of *Nature* arrived safely in the United States. This issue contains a "Letter to the Editor" announcing a discovery in the field of fluid flow. This may be the first important discovery since Hodgson's announcement in 1917. Why do I think so? Well, in the first place it's exactly a quarter-century since Hodgson's disclosure. In the second place I noticed Nissan's letter in *Nature* almost the same day that I received Professor Binder's important disclosure of his "*T*" Number. No, your editor is not superstitious: in the third place, the latest issue of *Science News Letter* (which is published under the auspices of the great American Association for the Advancement of Science) features Nissan's discovery. In the fourth place, Nissan suggests a novel application to automatic control of flow rate which is right up Instrumentation's alley. Anyway, judge for yourself! —MFB

[1] *Proceedings Institution of Civil Engineers*, Vol. 204, Part 2, 1917, pages 104-293. (Actual reference, pages 186-191. Note particularly Figs. 32, 33 and 35.)

[From *Nature*, Vol. 149, No. 3783, May 2, 1942, pages 501-502]

Flow of Liquids in the Critical Region

IN EXPERIMENTS on the flow of water in a long copper tubing, it was found that the inlet pressure must be maintained free from disturbances to the highest degree possible if flow in the critical region is to be analyzed. When extraneous disturbances were eliminated, the flow in the tube falling between Reynolds numbers 1,000 and 5,000 was found to fall into three distinct classes, all of which were different from both the viscous and the turbulent regimes. Strictly speaking, only the regime existing between 2,200 and 2,500 Reynolds numbers in the present system showed the ordinarily accepted criteria of critical flow. Nevertheless, as both the regions between 1,000 and 2,200 and between 2,500 and 5,000 fall outside the laws of either viscous or turbulent regimes, they are treated here as "pre-critical" and "post-critical" regimes.

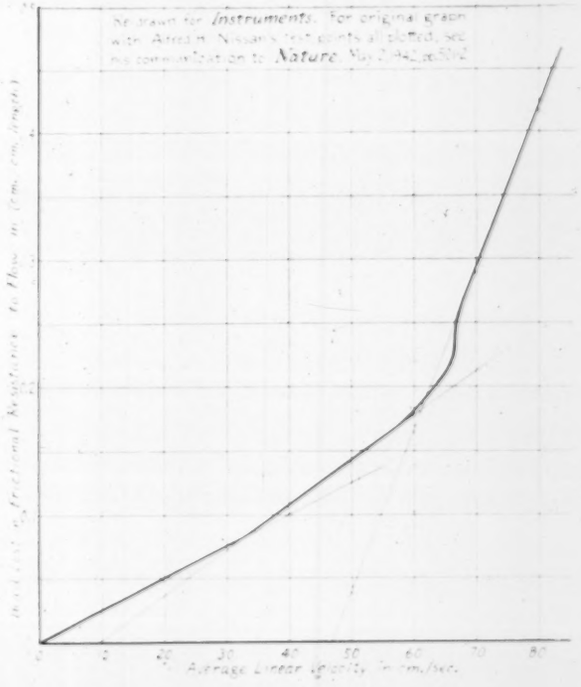
In the accompanying graph, the corrected head lost per unit length of pipe is plotted against the average linear velocity of the water in the pipe, for values of Reynolds numbers ranging between 240 and 2,800 approximately. It is seen that there are four distinct sections of the curve.

(1) Up to *circa* 1,000 Reynolds numbers, the ordinary straight line of the viscous regime obtains, characterized by (*a*) passing through the origin, and (*b*) by its slope being governed solely by the viscosity of the fluid insofar as the properties of the fluid are concerned.

(2) Between 1,000 and 2,200 Reynolds numbers approximately, a second straight line obtains. This straight line differs from the first in that (*a*) it does not pass through the origin: (*b*) it has a higher value for its slope than the first line.

(3) Between Reynolds numbers of 2,200 and 2,500 approximately, the curve rises almost vertically upwards in the direction of the pressure loss. It is in this and the following region that it becomes essential to eliminate all disturbances from the entry. As mentioned above, strictly speaking this is the critical region.

(4) Between 2,500 Reynolds numbers and about 5,000, above which the curve shows a definite curvature characteristic of the turbulent regime, there is yet another straight line. The graph goes up to 2,800 only, but other experiments showed that curvature begins above 5,000. This straight



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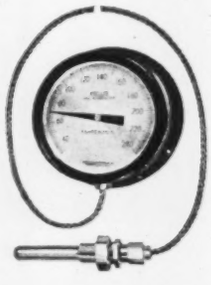

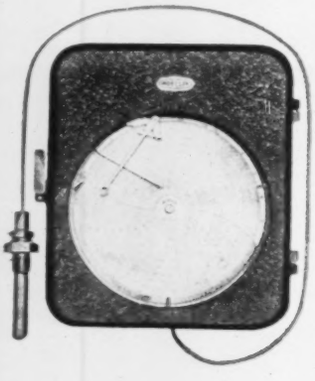

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line again does not pass through the origin, and has a steeper gradient than both the viscous and "pre-critical" lines.

Another important point in connection with the lines which is not evident from the graph, is that in the critical region a change of 25 percent in the viscosity of the flowing water appeared to have no effect on the position or slope of the lines, especially the "post-critical" curve. Of course, the viscosity is of paramount, but indirect, importance, in that it influences the type of régime obtaining in the pipe.

Thus, it appears that the classification of flow as viscous, critical and turbulent is an over-simplified system. In unpublished work carried out in this Department and to which reference has already been made[1], it became evident that when flow is at extremely low rates, in a medium of high specific surface, such as might obtain in the flow of fluids through porous strata in oil, gas or water production, then the law of frictional resistance due to flow did not follow the laws of the viscous régime. In other words, a "sub-viscous" or "pre-viscous" régime of flow appears to exist. Flow then adopts the viscous régime when the velocity is increased and, as is seen here, passes through an intermediary type of flow before it enters the critical régime. Before entering the fully turbulent type of flow, it passes through still another distinct type, the post-critical régime. At extremely high Reynolds numbers the flow becomes further complicated by the production of certain sound waves.

A final point of interest here is the possibility of using the vertical section of the graph in the production of accurately constant rates of flow in instrumental and process controls, as a very great change is required in the overall head loss to produce a small change in the rate of flow.

It is hoped to publish a fuller report than this elsewhere.

ALFRED H. NISSAN.
Department of Oil Engineering and Refining,
University, Birmingham, 15.

[1] A. H. Nissan, *Nature*, Vol. 148, Oct. 25, 1941, page 503.

[From *Science News Letter*, Vol. 41, No. 22, May 30, 1942, page 340]

Liquid Flow Through Pipe Assumes Five Different Forms

Three Kinds Previously Observed Declared Not Enough; Other Types Occur When Velocity is Very Low or High

THE FLOW of oil, gasoline and other liquids through a pipe assumes five different forms as the velocity is increased, instead of only three as generally supposed, according to a communication to the British journal *Nature* from Alfred H. Nissan, Department of Oil Engineering and Refining of Birmingham University.

The three kinds of flow previously observed are the smooth, the critical and the turbulent. These are assumed in succession as the velocity of flow is increased. For smooth flow the frictional loss is low; for turbulent flow it is high. In the short critical range between, the loss changes rapidly from a low to a high rate of increase with velocity. The flow here is partly smooth, partly turbulent.

These three stages can be illustrated by water flowing from a tap, by turning the tap on gradually.

Mr. Nissan, however, declares this classification to be an over-simplification. He finds two other distinct types which might be called the sub-smooth and the super-turbulent.

When the velocity is very low, the frictional loss increases with the velocity at a lower rate than for smooth flow. This sub-smooth type occurs when oil, gas or water seeps through porous layers in the earth.

When the velocity is very high, certain sound waves are produced which further increase losses and make a fourth type.

The usual methods of calculating flow fail in these cases, he says. They give results too low or too high, which may sometimes be a serious error.

Maintenance and Servicing of Electrical Instruments

By JAMES SPENCER

Foreman, Instrument and Relay Testing, Westinghouse Elec. & Mfg. Co., Newark, N. J.

CHAPTER VI

FREQUENCY METERS

(Continued)

MOVING IRON TYPE

Another of the present-day frequency meters is the moving iron type shown in Fig. 29. This type differs from the previously-described types in that two sets of stationary coils are used and the moving element includes an iron vane instead of coils.

In Fig. 29 it will be seen that in general this type of frequency meter includes all the usual parts such as base, pointer, bumpers, dial, covers, etc., found in other types. Two pair of fixed coils, assembled as shown in Figs. 29 and 30 (one pair inside of the other) constitute the field-produc-

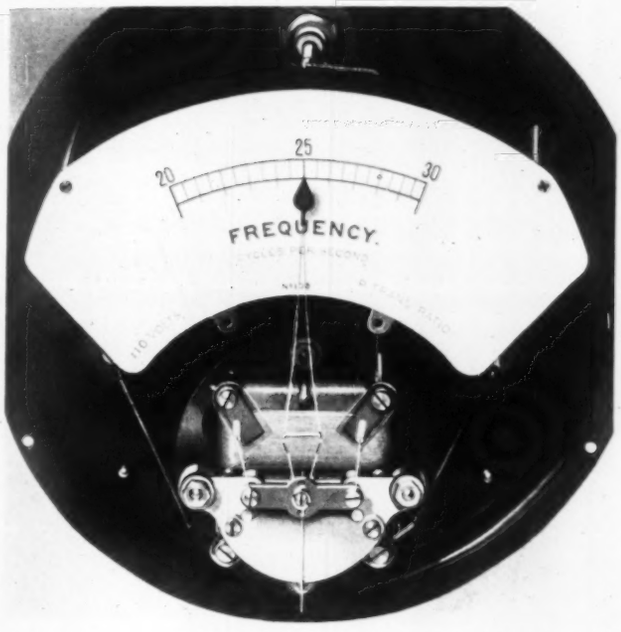


Fig. 29. Weston moving-iron type frequency meter with cover removed.

ing element. Air damping as outlined in Chapter II is utilized to suppress the oscillatory motion of the moving element. The moving vane is made of an iron alloy having low loss characteristics. This vane is positioned on the shaft as shown in Fig. 30 so as to be in line with the pointer. The steel pivots of the element shaft operate in V-shaped sapphire jewels. The jewels are set in screw type mountings to allow for accurate adjustment of end-play. The aluminum damping vane is of the single-vane type and operates in the air chamber of the movement frame. A resistor-reactor, shown in Fig. 31 with case removed, is used with this type of frequency meter.

Principle of Operation

The network circuit of this instrument is in the form of a Wheatstone bridge as shown in Fig. 32. One coil of the instrument is connected in series with one of the reactors X_1 and the other coil is in series with one of the resistors R_2. The common connection of the two fixed coils is connected diagonally across the bridge to the connection between the reactor X_2 and the resistor R_1. Harmonic suppressor X is connected in series with the bridge to damp out any harmonics or variations of wave-form.

The frequency indication of this instrument is dependent upon the position of the resultant field of the two fixed coils 1 and 2, Fig. 32. The iron vane, being free to move, always tends to assume a position along the axis of the resultant field. The network is adjusted so that at normal frequency, usually 25 or 60 cycles, the system (considered as a bridge) is in electrical balance. With a change in frequency, the system becomes unbalanced, causing a shift in the position of the resultant field, hence a change of position of the moving element. With an increase in frequency, the reactance increases reducing the current flow in the reactor legs X_1 and X_2 of the bridge and increasing the relative current flow in the resistance legs R_1 and R_2. From this it will be seen that with a frequency increase the current flowing in the coil connected to R_2 will be greater than that in the coil connected to X_1 and hence a clockwise shift of the re-

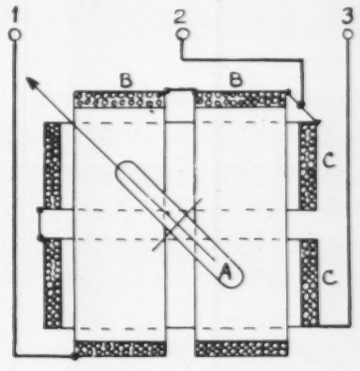


Fig. 30. Internal connections of Weston moving-iron type frequency meter. A—moving iron; BB and CC—fixed coils.

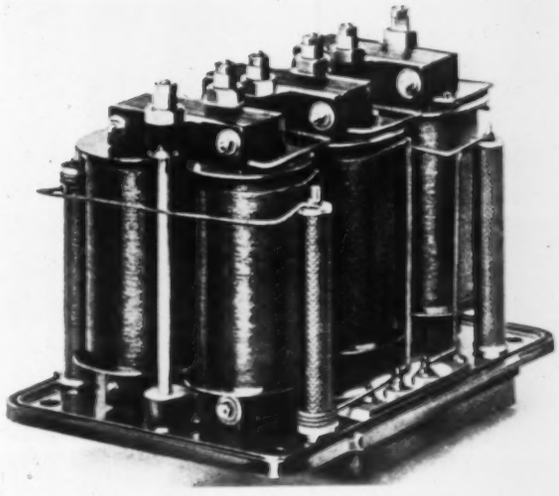


Fig. 31. External resistor-reactor used with Weston moving-iron frequency meter.

sultant field will result. With a decrease in frequency, the opposite effect results and the resultant field will be shifted in a counter-clockwise direction.

The narrow-range frequency meter of this type differs in its network arrangement by reason of the use of a capacitor for securing greater sensitivity.

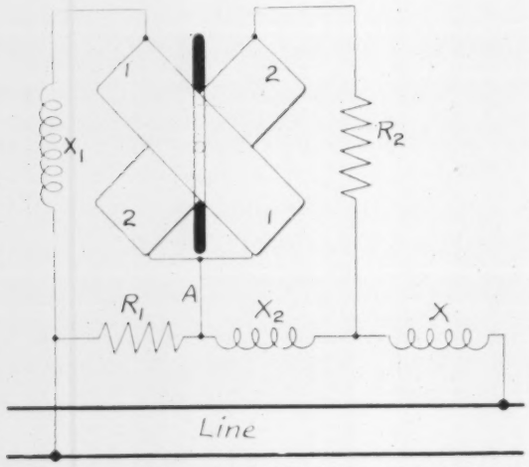


Fig. 32. Wiring diagram of the Weston moving-iron frequency meter.

Inspection and Testing

Periodic inspections and adjustments of this type instrument should be made as already outlined under "Inspection and Tests" in the section on the Bridge Type in this Chapter. Calibration adjustments may be made by changing the values of the resistances R_1 and R_2 or by adjustment of the iron in the reactors X_1 and X_2. The resistances may be changed by substituting a new resistor or by adding or removing wire from the spool. The reactance may be changed by loosening the stud nuts at the top of the reactor Fig. 31 and raising or lowering the iron cores: This changes the air gaps of the cores. After making reactance changes, be sure that all the nuts and bolts are absolutely tight to avoid shifting of parts that affect calibration. Slight changes of calibration may be due to element unbalance and can be corrected by rebalancing the element.

CHAPTER VII

POWER FACTOR METERS
(AND RVA METERS)

Power factor is that quantity by which the effective volt-amperes of a circuit must be multiplied to give the true power of the circuit. Power factor is expressed in percent of true power. It is the cosine of the angle of lag or lead of the current in a circuit to the impressed voltage. In general there are two types of indicating instruments for measuring power factor. One operates on the moving-iron principle and the other on the electrodynamic principle. Both of these types are made to indicate directly the percent power factor of a system. To obtain this measurement otherwise would require the use of three or more instruments (ammeter, voltmeter and wattmeter) and calculations as shown in the formula below.

$$P.F. = \frac{\text{WATTS (as read on wattmeter)}}{\text{VOLTS (read on voltmeter)} \times \text{AMPERES (read on ammeter)}} = \frac{\text{True Watts}}{\text{Apparent Watts}}$$

(VA for 1φ)
(2VA for Bal 2φ)
(1.73VA for Bal 3φ)

Power factor meters are used on panels where continuous readings of power factor is desired or where it is required to control the power factor of the circuit.

A Contribution to the War Effort

IN normal times it is inadvisable for users of electrical instruments (except users such as utilities with full-equipped service laboratories) to do any work which involves opening up the case.

But this national emergency has created a shortage of electrical instruments, so that even plants enjoying priority have to wait. The top shelves of stockrooms are being searched for old instruments, "Irreparable" instruments are being "repaired." And —perhaps most important—all instruments in use must be maintained in good condition . . . by the users. Hence the crying need for this serial—the first and only one of its kind.

Power factor meters in general are standard for single-phase and three-phase balanced circuits, two-phase being special (though a single-phase instrument is often used for two-phase circuits). The single-phase and three-phase instruments will be discussed in this chapter, taking first the induction type and then the electrodynamic type.

MOVING IRON TYPE

Construction.

The single-phase and polyphase power factor meters of the moving-iron type are identical in construction except in the winding of the potential coils.

Construction details of two typical power factor meters designed for rear connections are as shown in Figs. 1 to 6. The five brass terminals that project through the pressed iron base have a molded sub-base that serves as an insula-

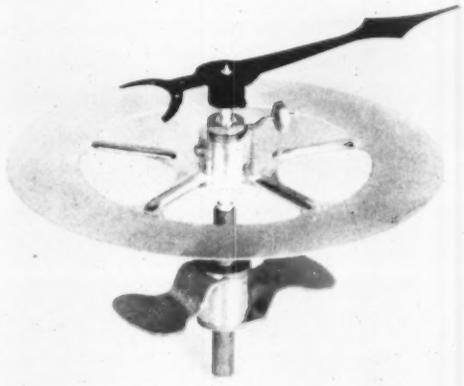


Fig. 1. Moving element of a moving-iron type power factor meter, showing all the moving parts. (Figs. 1 to 4 show Westinghouse instruments.)

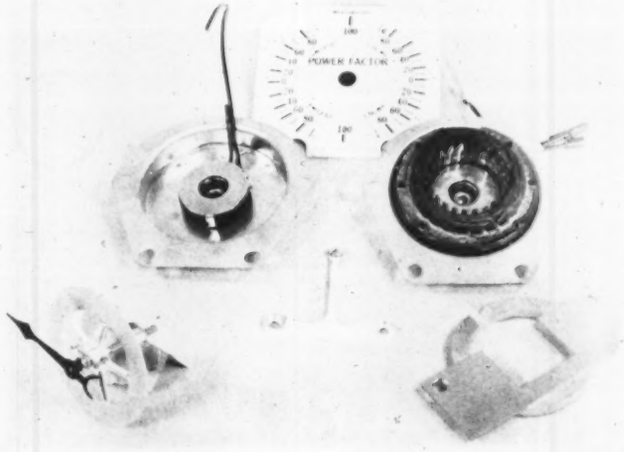
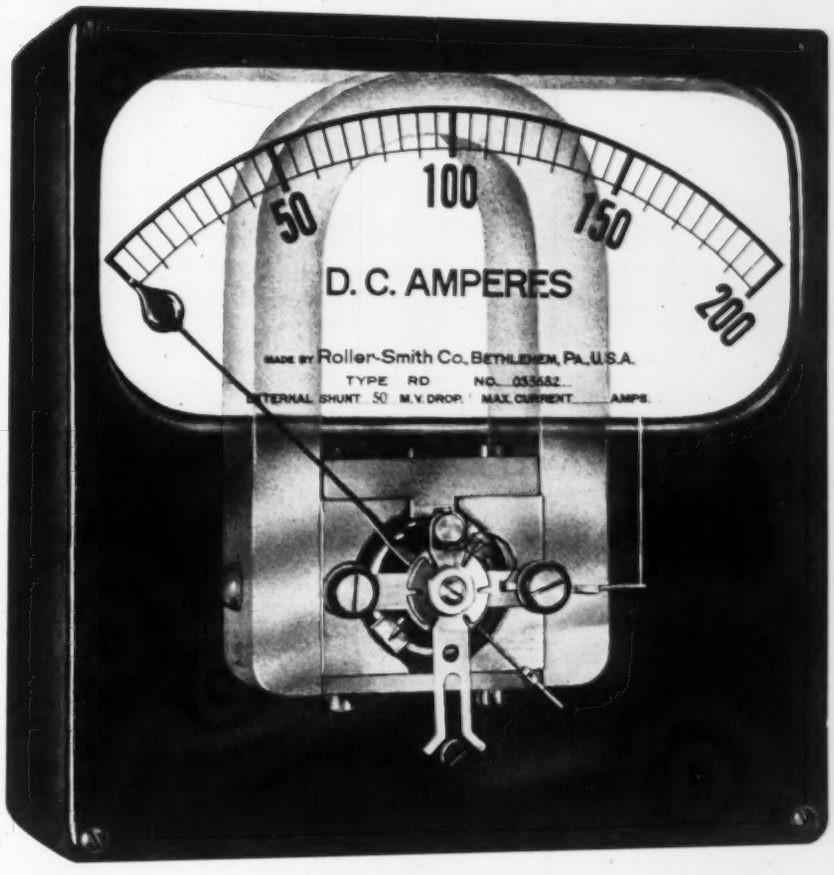


Fig. 2. Mechanism of moving-iron type power factor meter dismounted, showing all main parts.

BEHIND THE DIAL



A New Movement with 4 Improved Features

You'll find no difference in the **exterior** appearance of the Roller-Smith types RD and SD switchboard instruments. The attractive cases . . . the easy-to-read dials are unchanged.

But behind the dial is a completely new movement. Compare its performance with any other instrument available today . . . and you'll see the value now offered in the new RD and SD designs.

These 4 NEW FEATURES will improve Your Instrument Performance

1. Overload capacity increased to 30 times normal by use of one piece pointer cross arm construction. Therefore, the instrument can sustain repeated overload shots and retain its normal accuracy.

2. Temperature errors only .09% per degree Centigrade change.

3. Improved damping results in an overshoot of only 1 25 of the distance the pointer is deflected. Thus readings can be made more quickly.

4. Time required for pointer to come to rest is less than one second.

In addition you'll find such features as 1% accuracy . . . 750 volt insulation . . . generous size tungsten steel magnets . . . and enameled dials.

Even though our efforts are devoted primarily to War production, improvements constantly are being made in R-S products. This is your best indication of even better equipment to be available in the future.

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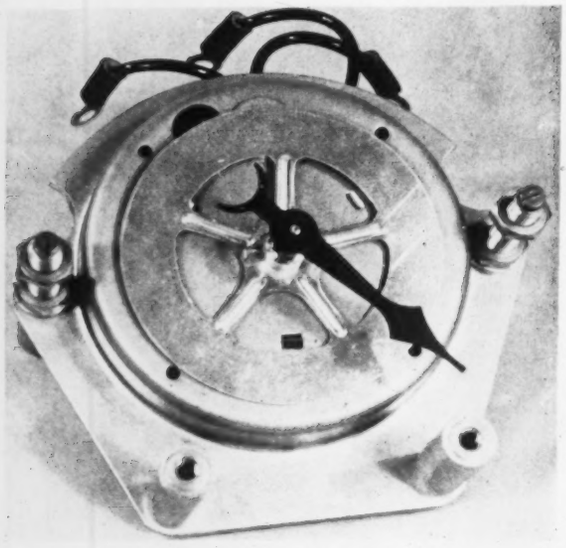


Fig. 3. Mechanism of moving-iron type power factor meter assembled.

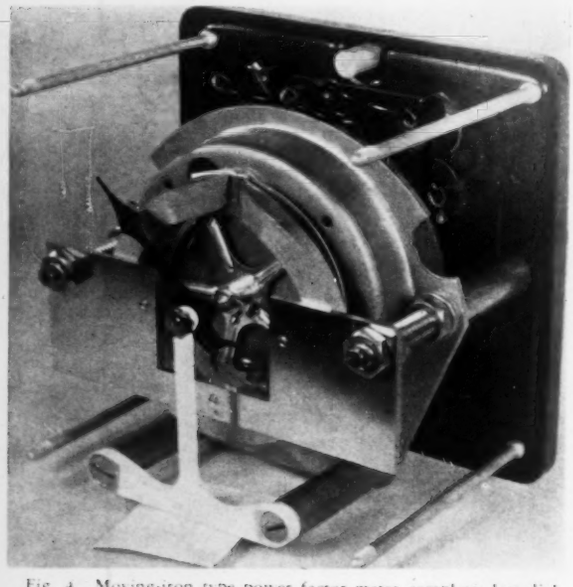


Fig. 4. Moving-iron type power factor meter complete, less dial and case.

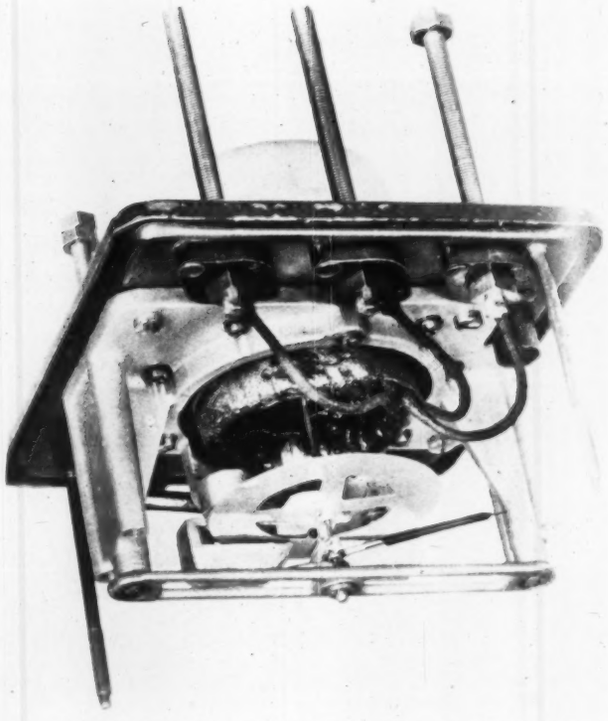


Fig. 5. Internal construction of the General Electric Co.'s "Model AD6E-Y38" 5-amp. 60-cycle 3-phase 3-wire moving-iron type power factor meter, less dial and case.

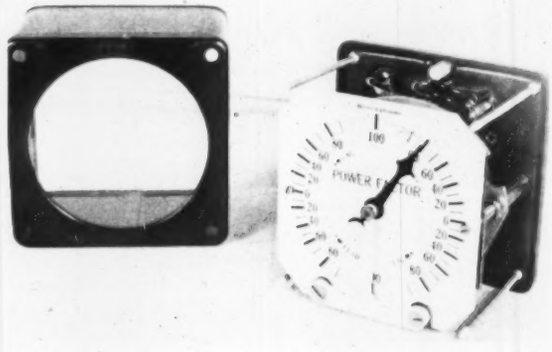


Fig. 6. Westinghouse moving-iron type power factor meter, with cover removed.

tor and also as a means of mounting the terminals to the main base. The pressed steel cover with the necessary packing to make it dust-proof has a full glass front for viewing the dial. In the Westinghouse instrument four screws are required to attach the cover to the base and two iron studs screwed in the base serve as mounting bolts.

The stationary element of a moving-iron type power factor meter consists of current and voltage coils spaced, wound and connected as shown in Figs. 7 and 8. Fig. 7 is for single-phase and Fig. 8 is for polyphase. The coils are placed in a ring core made of soft iron laminations.

The moving element comprises a brass shaft with hard steel pivots at both ends. The shaft runs through the center of the coil assembly and carries the soft iron vane that operates between the current and voltage coils as shown in Fig. 9. The aluminum damping vane and the channel-constructed pointer are also attached to the shaft.

Other parts used to complete the assembly of this instrument are the hard steel damping magnet, the metal dial and the bridge that holds the upper sapphire jewel. The two-piece iron casing around the mechanism as shown in Fig. 2 is used to support the element and to mount the parts on the base as shown in Figs. 3 and 4.

The single-phase power factor meter includes an external resistor-reactor made up of a spool resistor and a reactor coil mounted in a metal box with a screen side as shown in Fig. 10. The polyphase meter takes three external resistors, a typical example of which is shown in Fig. 11, consisting of clay spool wound resistors mounted in metal case.

Principle of Operation.

The rotating field of the single-phase power factor meter is made possible with the split-phase voltage circuit and the arrangement of the voltage coils. The three-phase meter has three voltage coils spaced 120° apart to give the same conditions. Both these arrangements are shown in Figs. 7 and 8. The current coils in both the above cases are connected in series with the circuit to be measured and magnetize the soft iron vane of the moving element when a current flows. As the magnetized iron vane is attracted or repelled by the rotating field, it takes a position where the zero of the rotating field occurs at the same instant as the zero of its own field. In this way the position taken indicates the phase angle difference between the voltage and the current of the circuit, and by comparison with a standard of known accuracy is calibrated directly in per cent power factor.

...nd Inspection.

... phase.

...nect p.f. meter and resistor-reactor to the circuit as ... in Fig. 12 using a suitable standard for calibrating. ... test the moving parts to be sure they move freely ...ut friction. If the p.f. meter is free of friction or ...ng, adjust the phase shifter to get a reading of 0% ... the standard and set the pointer on 0% lag of instru- ... under test.

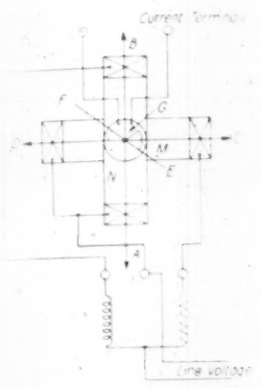


Fig. 7

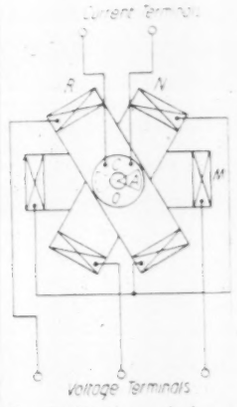
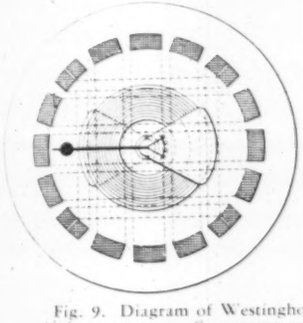


Fig. 8. Diagram of three-phase power factor meter.



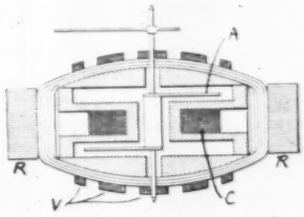


Fig. 9. Diagram of Westinghouse polyphase power factor meter. *A*—iron armature. *C*—current coil magnetizing armature. *R*—laminated iron ring. *V*—voltage coils production rotating field.

Fig. 10. Typical resistor-reactor used with a single-phase power factor meter.

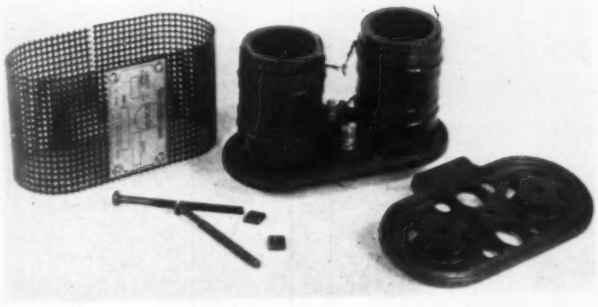


Fig. 11. Typical resistor used with polyphase power factor meters.

Disconnect instrument from circuit and balance* the element on quarter points by applying point to back of damping disk.

Reconnect instrument to circuit and check 0% lag; and, if changed, reset. Next, check the 100% point and, if the instrument pointer reads on the lag side, close the air gap in the reactor coil of the resistor-reactor. If pointer reads on the lead side, open the air gap. If 0% lead is correct, dial is evenly quartered and may be marked.

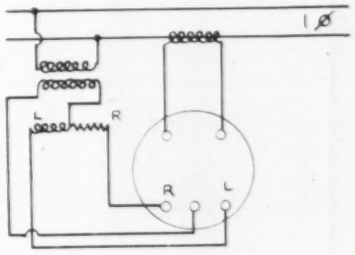


Fig. 12.

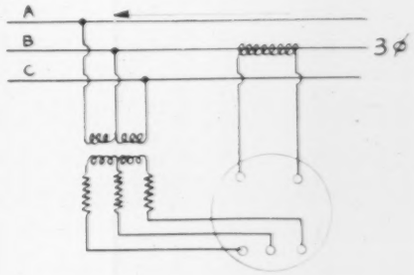


Fig. 13.

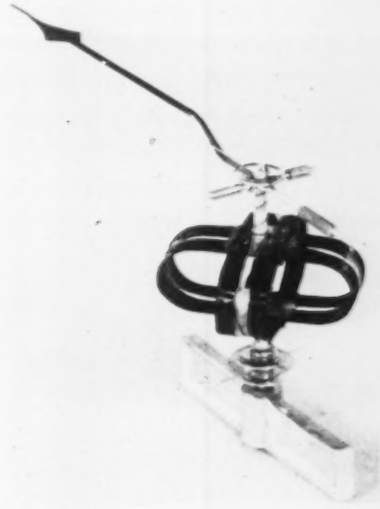


Fig. 14. Showing the cross-coil type element for a power factor meter.

A mechanical inspection is now given the instrument for proper end play* and balance* of the movement. The damping disk should be true and be spaced evenly between the damping magnet and the keeper. All connection should be properly made, screws and nuts should be tight and free from burrs or other blemishes. Friction should not be present in the instrument and it should be well cleaned.

After the mechanical inspection the instrument should be again connected to the test circuit and checked with a suitable standard after which it should be ground tested (1500 volts from terminals to case and 500 volts between windings).

Three-phase.

The test of the three-phase instrument is the same as that of the single-phase except as follows: after balance reconnect instrument to circuit as in Fig. 13 and recheck

*End play adjustment and balance adjustments have been discussed at length in Chapter I.

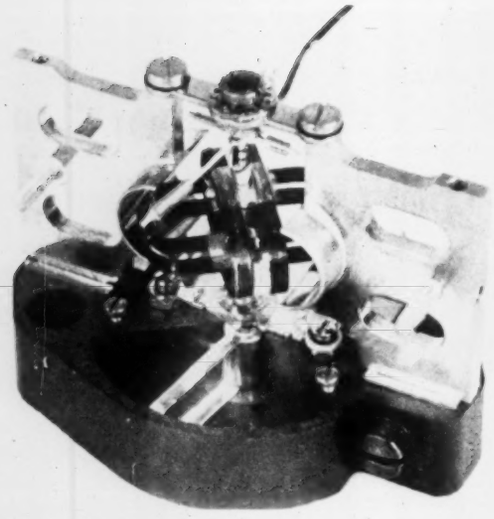


Fig. 15. Westinghouse cross-coil type power factor meter element mounted in its frame, with damping chamber open and fixed coils not yet in place.

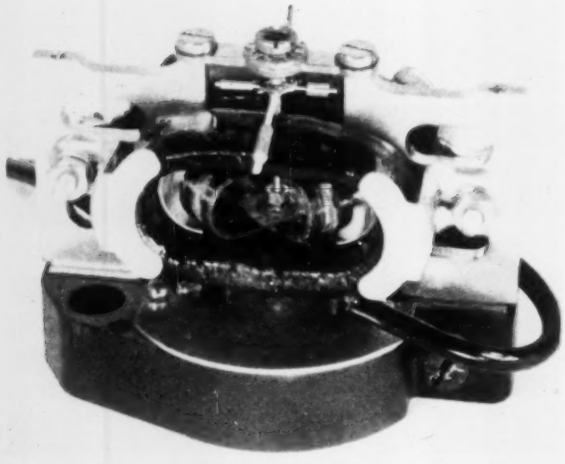


Fig. 16. Mechanism of cross-coil type power factor meter. Note that coils and damping-chamber covers missing in Fig. 15 are in place.

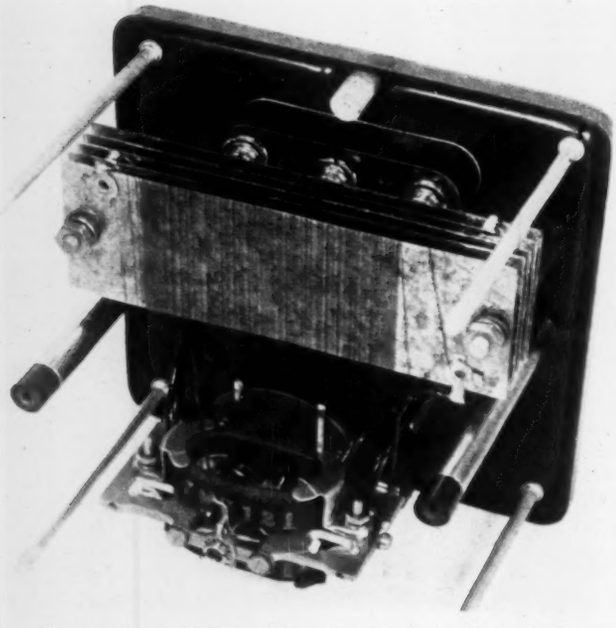


Fig. 17. Cross-coil power factor meter less dial and case, showing internal construction and connections.

zero lag and if changed reset. Next, check other quarters which should be approximately on, if not change balance slightly to correct.

ELECTRODYNAMIC TYPE

Construction.

The electrodynamic type power factor meters are standard in switchboard types, for both single-phase and polyphase applications. The single-phase and three-phase switchboard power factor meters are practically identical in construction.

Construction details of two typical instruments are shown in Figs. 14 to 20. The pressed steel base, beside shielding the movement from external fields, supports the molded sub-base of the element, the sub-base of the terminal assembly and the three brass mounting studs. The brass terminal studs of the instrument are mounted in a molded housing that extends through the base for rear connections. The sub-base of the element assembly is molded with two integral chambers used for air-damping purposes. The ele-

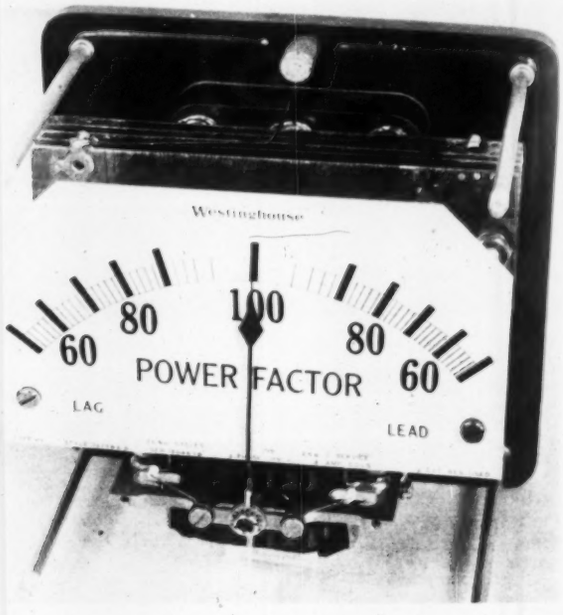


Fig. 18. Cross-coil electrodynamic type power factor meter complete less case.

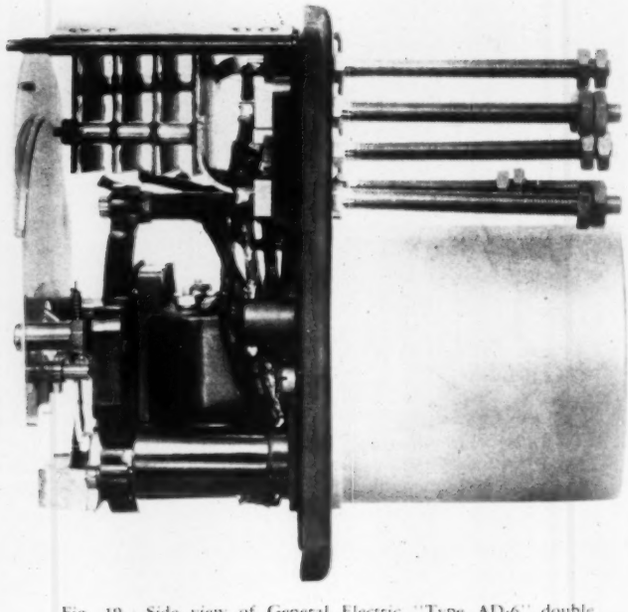


Fig. 19. Side view of General Electric "Type AD-6" double element type power factor meter. Element construction is similar to that of polyphase wattmeter.

brackets are connected at the top by a bridge connec- hat holds the top sapphire jewel. These brackets also ort the two stationary coils which are attached by four gs. The dial is also supported by the element brackets. e moving element, Fig. 14, consists of two coils placed ght angles to each other on an aluminum shaft with steel pivots at both ends. This shaft also carries the

(Continued on Page 220)

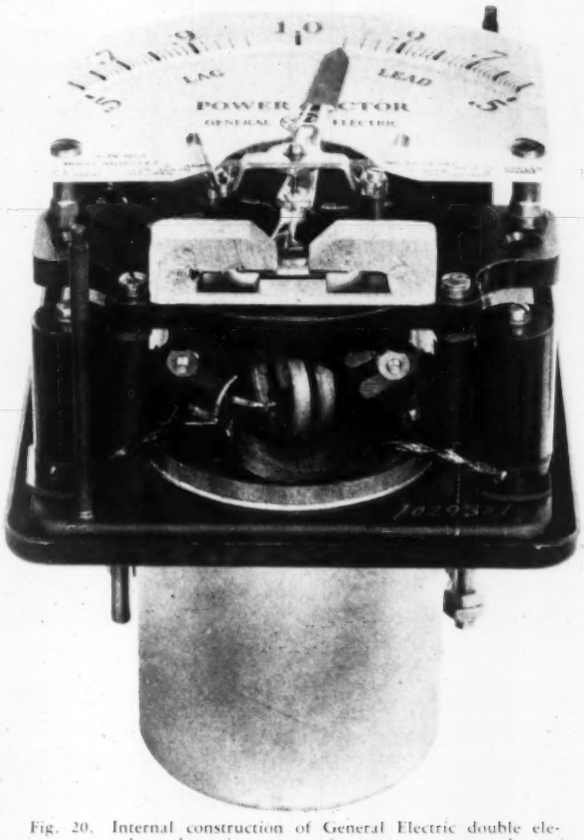


Fig. 20. Internal construction of General Electric double element type electrodynamic power factor meter—one element showing.

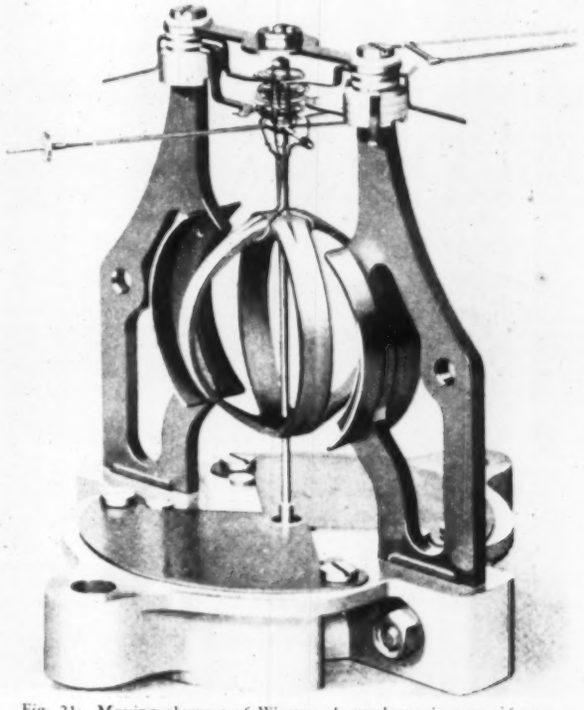


Fig. 21. Moving element of Weston electrodynamic power factor meter, assembled in element frame.

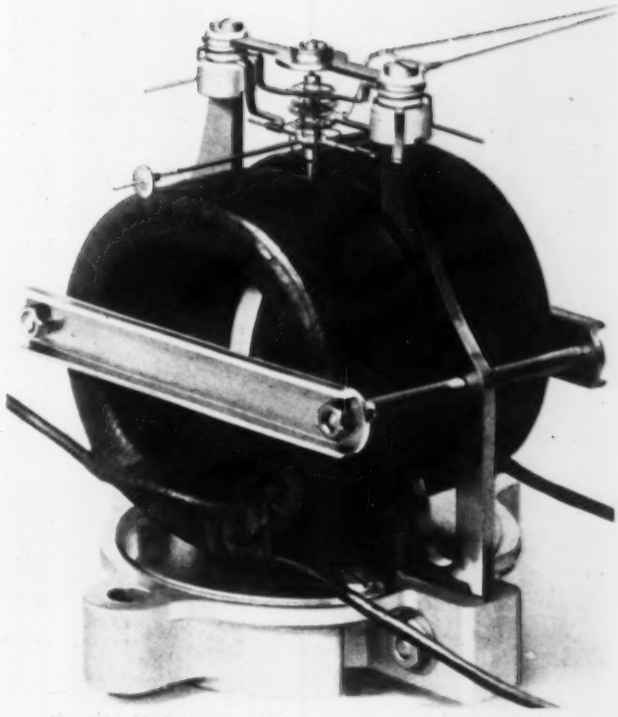


Fig. 22. Mechanism of Weston cross-coil electrodynamic type power factor meter.

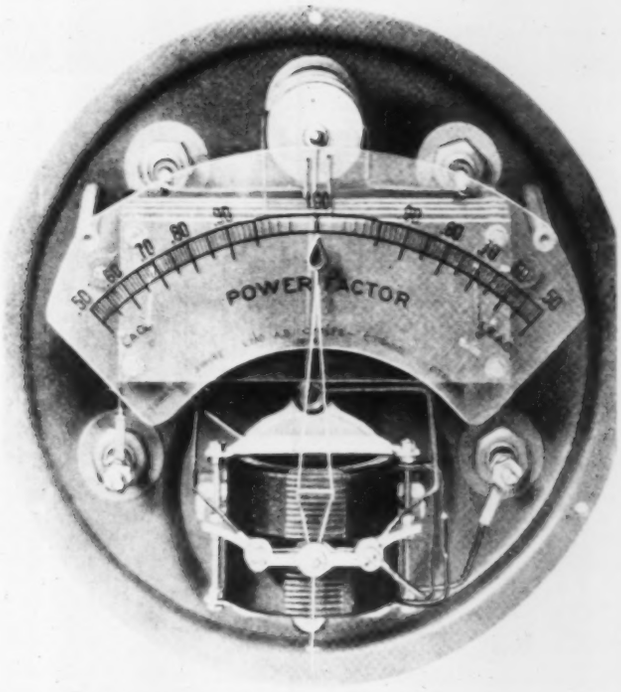


Fig. 23. Phantom view of interior of Weston cross-coil electrodynamic power factor meter.

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Fig. 24. Reactor for use with Weston power factor meter.

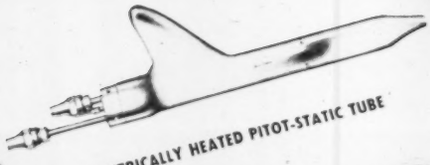
AIR SPEED INDICATOR

TELEGON REMOTE INDICATOR
(Quadruple Engine Unit)

SENSITIVE ALTIMETER

DIRECTION INDICATOR
(Compass)

MANIFOLD PRESSURE GAGE



ELECTRICALLY HEATED PITOT-STATIC TUBE

CRADLE OF PRECISION

Many of the world's most important contributions to precision aircraft instruments have been cradled on the Kollsman drafting board. The first practical Sensitive Altimeter and the Direction Indicator are notable examples.

Kollsman craftsmen have, in fact, either created or refined almost every type of precision aircraft instrument.

Those shown here are but a few of the more familiar types—their faces open to view and easy to read, which is typical of Kollsman design.

These instruments and many others—many of them only ideas stirring in the minds of Kollsman engineers in our great research laboratories—are Kollsman's contribution to aircraft of the United Nations at war today . . .

And to the commercial and private planes that will circle the earth in a world at peace tomorrow.

VERTICAL SPEED INDICATOR

TACHOMETERS
(Direct and Remote Indicating)

ENGINE GAGE UNIT

FREE AIR THERMOMETER
(Ice Warning Indicator)

KOLLSMAN
AIRCRAFT INSTRUMENTS
Division of
SQUARE D COMPANY
ELMHURST, NEW YORK • GLENDALE, CALIFORNIA
DETROIT, MICHIGAN

PPLICATIONS OPERATING PRINCIPLES INSTALLATION MAINTENANCE

Aviation Instruments

Navigation Automatic-piloting Power plant Automatic-landing Aerological
Communication Flight-testing Production Instrument-testing

Vol. I, No. 1 GUEST EDITOR: None for this first issue; see announcement below. June 1942

A Magazine Within a Magazine

By Major M. F. BEHAR, Editor of *Instruments*

IT had to come! It was dictated by the success of the two Special Aviation Issues we brought out—in October 1941 and last April. The number of subscriptions to *Instruments* has jumped approximately 50%, mostly from the field of aviation and mostly in "groups" organized by enthusiastic subscribers who hailed our October and April issues as just what they and their associates needed.

In short, YOU asked for this Department. Some of you, holding important positions in manufacturing, in airlines, in government and in education, *specifically suggested* that the kind of material we published in October and April should appear regularly — month after month instead of at six-month intervals. This took us by surprise because the field of aviation has been and is excellently served by the magazines issued by the Institute of the Aeronautical Sciences and by privately-owned publishing companies —not to mention those great fountain-heads of information the N.A.C.A., the Bureau of Standards, the Guggenheim-endowed universities and other splendid institutions. We said so to our friends. We explained that *Instruments* never competes with other services.

Our friends told us that there would be neither competition nor duplication, because there was a real gap to be filled—a gap which might be described as "Applications, Operating Principles, Installation and Maintenance" of *all* instruments pertaining to aviation. Perhaps no single friend used these exact words, but from discussion of the needs to be filled, the nature and scope of this Department began to emerge clearly—a magazine within a magazine, serving the aviation industries and Services in the same unique way that *Instruments* serves industry, science, education and government in general. Hence the words in capital letters above the words *Aviation Instruments*.

But what are aviation instruments? Answer: ALL measuring instruments, gages, meters, inspection set-ups, laboratory apparatus, telemetering systems, testing machines, automatic-control systems, etc., used in the design, production and testing as well as in the operation of aircraft. The kingdom of aviation instruments is limitless. Why then a separate department of *Instruments?* There are three reasons: (1) Because production instruments, for example, become aviation instruments only when used for manufacturing aircraft and engines and accessories. (2) Because many instruments are aviation instruments by virtue of their being *aeronautical* instruments—those pertaining to the operations of the air transport industries and Services. See page 216. (3) Because many instruments pertain exclusively to aviation and to no other field. Obvious examples: turn-and-bank indicators and other *aircraft* instruments.

So then the monthly Department *had* to be started. But one bottleneck was my time. True enough, I had planned and produced those Special Aviation Issues that weren't so bad, but six months apart—and simple arithmetic made me see that to do it once a month, 24 hours a day would not be enough for my actual work—even without my traveling again from Massachusetts to California and points between (which trips of mine helped make possible those two Special Aviation Issues). The ideal solution was at hand, in the persons of numerous friends of *Instruments*, all prominent in the aviation world, all from different sections of the country, all representing different viewpoints. For the first year it was decided that these Guest Editors should be drawn from aviation education and training. (Operations, manufacturing, etc., to be represented in future years by Guest Editors but *to be included from the start* in the contents of the Department. The "balanced diet" I am serving in this month's Department is a sort of model.) A few weeks ago I began to send out invitations. As we go to press, here is the schedule:

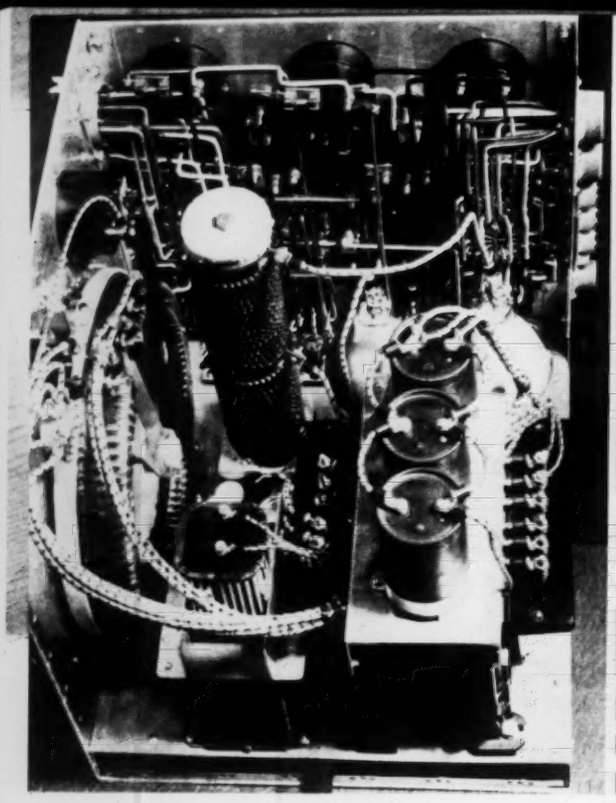
July—R. G. Ojers, Chief Instructor, Instrument Department Spartan School of Aeronautics, Tulsa, Oklahoma.
August—Professor J. N. M. Brown, Chairman of the Department of Aeronautical Engineering, University of Notre Dame.
September—G. S. Gooch, Instructor, Instrument Department, Shelby County School of Aeronautics, Whitehaven, Tennessee.
October—C. S. Smith, President, Chicago School of Aircraft Instruments.
November—J. C. Banks, Instructor, New York School of Aircraft Instruments.
December and After—Acceptances from Professor Alexander Klemin of New York University; W. J. Watkins of American School of Aircraft Instruments, Los Angeles; R. D. Bucklin, State Aviation Supervisor, V.E.D., Quoddy, Maine.

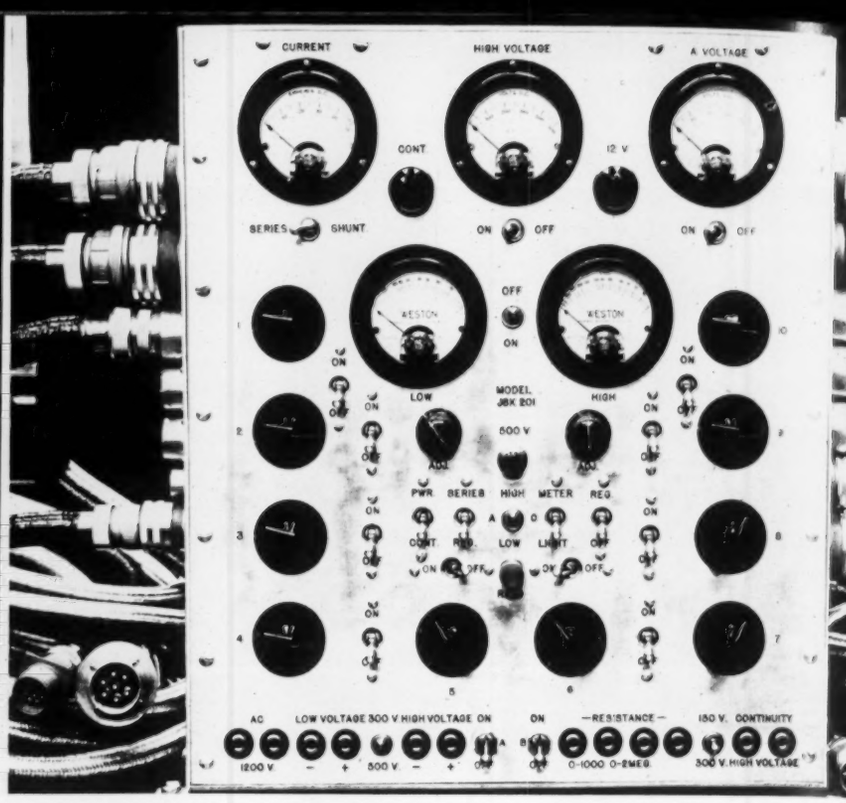
Mr. Ojers has already sent in his editorial, three articles and several short "helpful hints." Professor Brown is certain of getting technical articles from three (possibly four) of his friends. The success of the plan is certain. You, in turn, may be certain of good things to come!

ON this page every month, in a "box" like this, there will be a photograph and biography of the Guest Editor. Major Behar is not a Guest Editor but he has been persuaded to set a good example. However, he says that since his photograph has already appeared in *Instruments* the space can be saved. He adds that his biographical sketches have appeared in *Who's Who In Engineering* and other such books since 1927. But these sketches do not mention that he was an apprentice instrument-maker before he went to college; that he won the first American instrument making prize in 1905; that his interest in aviation began when he attended the first international aero meet in Reims, France, in 1909; that he has been a White House guest three times; that he founded and named the science of Instrumentation; that he has been in the military service continuously since he enlisted in the New York militia at eighteen and that he saw four years of active service in World War I. Major Behar was ordered to active service soon after Pearl Harbor and the reason why he is not in uniform right now is because the Army Medical Board found him unfit for "extended" active service and kept him in civilian clothes as a Reserve Officer—which decision raises his blood pressure still higher than measured by the Army doctors, confirming their decision and automatically keeping him in the service of *Instruments'* readers.
—Richard Rimbach, Publisher

THANK YOU!

In preparing to launch this department we have been assembling a reference library in which books are the minority—most of the material consisting of pamphlets, catalogs, journals, instruction sheets, wall charts, etc. Books and pamphlets sold by commercial publishers or by the Government Printing Office were purchased in the ordinary way. Much other material has been donated by publishers, institutions and manufacturers who generously included precious file copies (as evident from markings). Actions speak louder than words: this is unselfish collaboration!





EDITOR'S NOTE. Although we ordered the largest practicable reproductions of these two excellent photographs, some details easily seen on the originals are lost on the printed page. Among these details are the circuit numbers on the dials of the ten selector switches: Four 24-point, four 16-point and two 12-point, or a total of 184 circuit selections by means of the ten knobs—without counting the jack-plug possibilities.

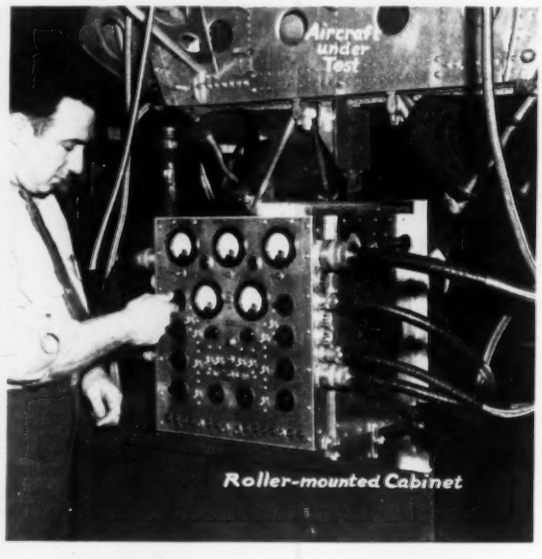
An Electrical Analyzer for Aircraft

By JAMES KUFFLER

Electrical Test Engineer, Republic Aviation Corp., Farmingdale, N. Y.

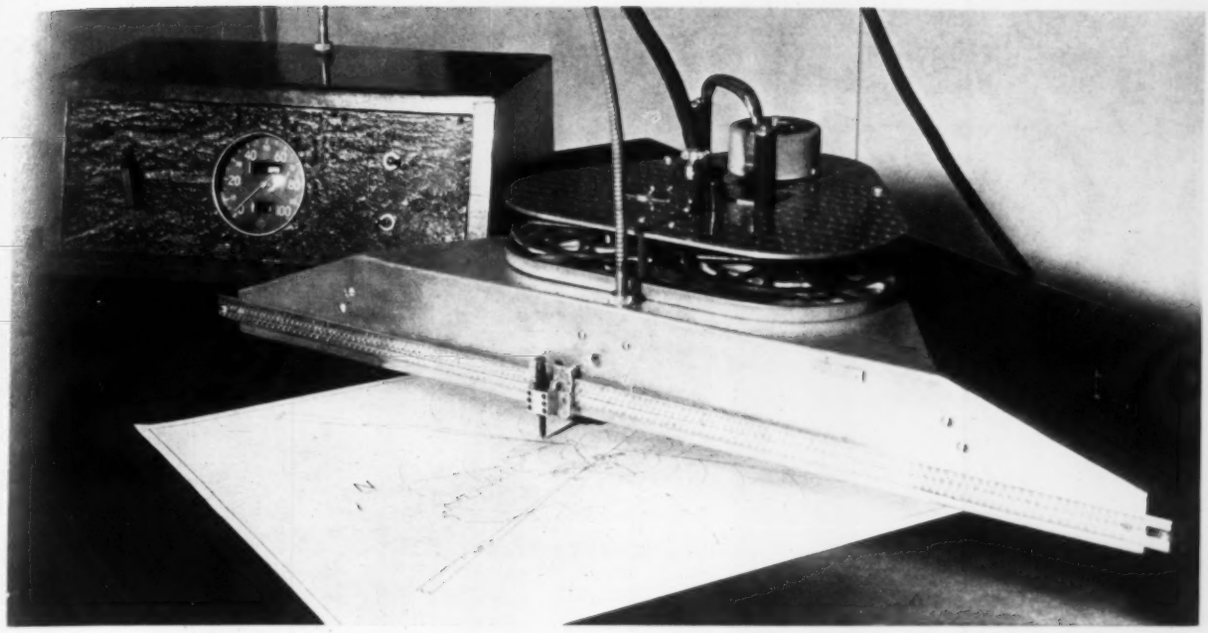
CONSTANTLY increasing production of the powerful Thunderbolts, the high-altitude pursuit airplane being manufactured for the U. S. Army Air Forces by Republic Aviation, has demanded every possible conservation of precious time. Every minute saved means that another Thunderbolt goes into Army service just so much sooner. Many minutes are saved through the use of the aircraft electrical analyzer devised in Republic's testing laboratories.

This analyzer was designed primarily to speed up ship testing and locate trouble without disconnecting any wiring. It also enables making adjustments on all electrical equipment prior to final assembly, for it is able to duplicate any missing circuits or loads. This is done chiefly by means of a voltage control arrangement, variable from zero to fifty volts, with a maximum output of 50 amperes. An automatic overload circuit eliminates any danger of damage to wiring or equipment.



Power is obtained from any a-c. 110-volt outlet, the alternating current being rectified by special equipment made to order. A five-bank selector system is used to isolate the circuits under test, enabling ten pick-up points at one time, which would be the maximum number of wires to complete any one circuit. A high-voltage power supply is also incorporated, with selective output to check equipment requiring up to 600 volts d.c. as well as 1200 volts a.c. Two types of resistance units enable a minimum and maximum measuring of resistance values. The type of test desired is selected by means of two selectors without the necessity of any plug changing on the ship under test. Circuit selection is made by breaking into junction plugs throughout the entire ship with corresponding plus—a system which gives access to every circuit. It also enables a direct analysis of any error in wiring assembly, naming exact location of circuits in error. The first application of this analyzer was made a year and a half ago. It has proven more than a boon to the assembly line. The analyzer is mounted on a roller cabinet, making a test available at any place desired. Contained in the lower section of the cabinet is a complete set of plug-in flexes for ships, giving an "all-in-one" unit. In addition, jacks are mounted on the front panel, allowing a complete selection of all power and measuring facilities for external use for individual testing and operations.

Another feature is adaptability to any model of aircraft without any rewiring of internal circuits. Ship mating end of flexes is the only change necessary. Test charts for each model of ship are all the operator needs as instructions for test operation. The wiring diagram of each entire ship is broken up into complete individual circuits, giving the operator a picture of the test. After several proof tests have been made on a new model ship, further instructions are not necessary as the operator has only to read the test chart and conduct the test accordingly. Wide variation of power output makes this unit adaptable to any type of service or testing.



A Wind Simulator for the Link Trainer

By ESTEN SHUMATE

Mid-Continent Airlines, Inc., Fairfax Building, Kansas City, Mo.

TWO First Officers, L. H. Hagie and L. H. Mouden, of Mid-Continent Airlines, Inc., have developed a wind simulator attachment for the Link Trainer. This automatic instrument employs the principle of a moving pen traveling at a definite rate to correspond to the "wind" desired. The simulator is remarkably accurate in reproducing all conditions of wind drift, for a wind from any fifteen degree angle, and can be adjusted to vary the wind velocity from ten to 100 miles per hour.

The Hagie-Mouden simulator comprises a cable-drawn pen carriage, mounted on a light track, and driven through a gear-reduction box by means of a flexible shaft. The track and pen-carriage unit mounts directly on the Link Trainer recording head, or "crab" as it is commonly called, by means of three screws, and requires no alteration of the Link Trainer in any way.

The wind simulator driving unit consists of a reversible variable-speed motor-driven control unit connected to a "wind" velocity indicator. This is connected to the pen unit on the Link Trainer "crab" by means of a flexible shaft.

The driving unit is encased to match the instrument panel mounted on the operator's desk.

The designers-and-builders believe that their wind simulator has several outstanding features to recommend it. It is extremely simple to install, and requires only the tightening of three screws and plugging of the drive unit into a convenient outlet to be put into operation. The comparative ease of manufacture and the minimum amounts of material and machining operations required to produce the simulator make it particularly valuable in fulfilling the need for this essential addition to all Link Trainers. It can sell for as little as $200 when produced on a commercial basis.

Because of the simplicity of the wind simulator, it is felt that it is of particular value during the war. Hagie and Mouden believe that their instrument device can be constructed from non-essential materials, and such a device is of great importance in the primary training of all pilots when they receive instruction on Link Trainers. The fact that it can be installed to any Link Trainer in five minutes' time makes it particularly adaptable to effective use.

The success of their wind simulator has encouraged Hagie and Mouden to develop other ideas and start construction of another attachment for the Link Trainer which will greatly increase the usefulness of the Trainer in giving instrument and radio flight training.

Hagie and Mouden (left and right in the picture) are First Officers with Mid-Continent. Hagie, in addition, has served as Link Trainer and Instrument Flight Instructor with MCA.

Mouden has served on the faculty of Iowa State College, where he received his degree of Master of Science. While at the College Mouden had considerable experience in technical research, and he has done a great deal of instrument making. He joined Mid-Continent in June of 1941.

Grounded but Fully Animated Airplane for

A COMPLETE AIRPLANE that—like the Link Trainer—does everything *but* take off is a unique addition to the training facilities of American School of Aircraft Instruments, Glendale, Calif.

The ship is a small, trim monoplane used in instrument maintenance instruction and practice, providing the students with a practical means of gaining advance experience in instrument installation, trouble shooting, testing and servicing. The craft also serves as a Gyropilot demonstration unit, and is used as a Gyropilot testing device, serving in the same manner as a Scorsby unit.

The plane, a former racing craft, is a fixed piece of equipment in the Sperry Shop of American School of Aircraft Instruments. The fuselage is mounted on a universal joint, and a telescoping tie rod runs between the left wing and the ceiling of the shop. A drive shaft runs through the fuselage and connects with an eccentric rod on an electric motor.

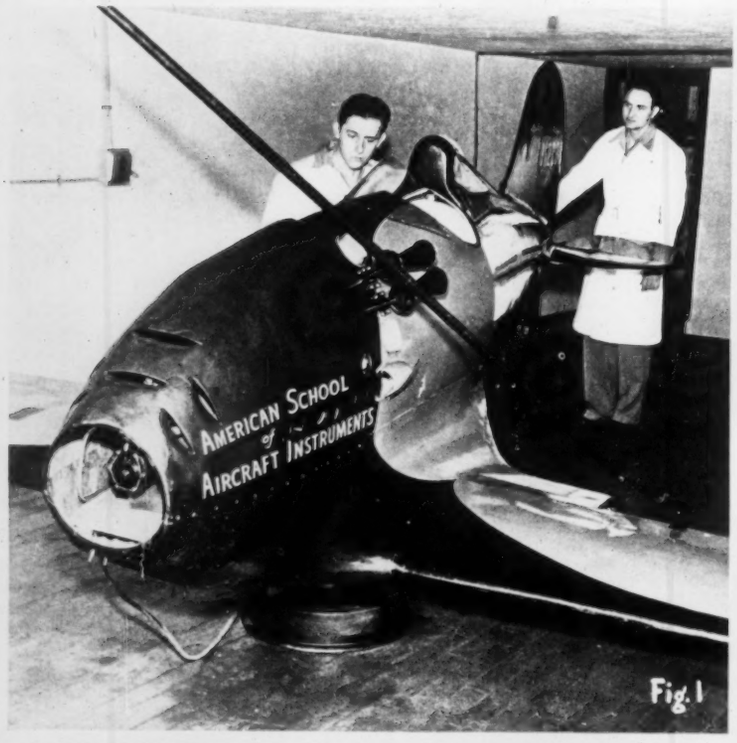


Fig. 1

Fig. 2

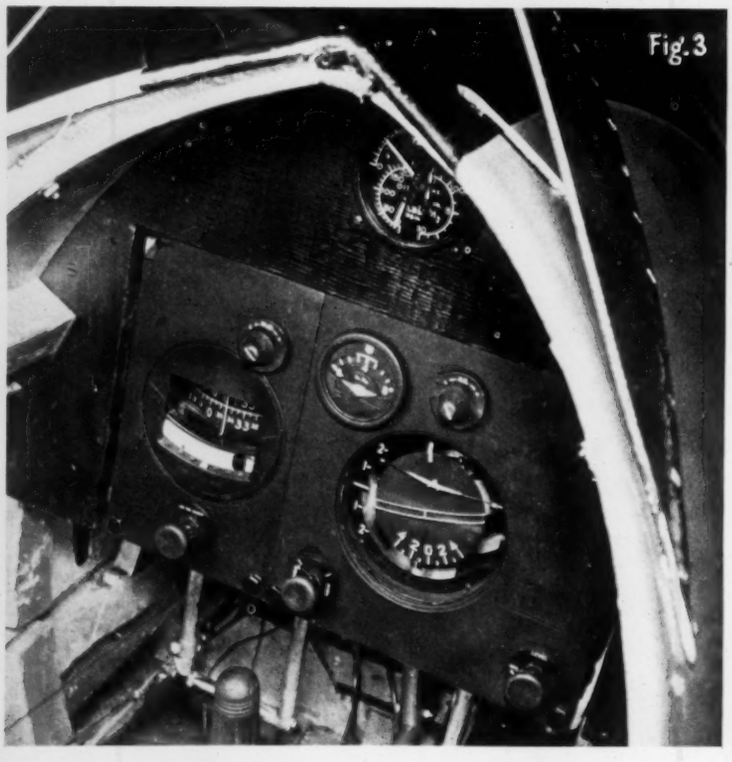


Fig. 3

Fig. 4

Checking and Demonstrating Instruments

When this motor is operated the plane can be made to roll, pitch and yaw. The instruments being checked in the craft at the moment indicate exactly as they would in an airplane under actual flight conditions. Operation of the instruments is effected through vacuum and hydraulic systems which respond to movement of the ailerons, elevators and rudder, and to separate manual control.

As the plane can be placed in the attitudes of level flight, banks, dives and climbs, it "brings to life" for the student the instrument operating principles he has learned, also the results of the instrument repair or overhaul work he has done.

Instructors at American School of Aircraft Instruments use the craft to demonstrate how the various instruments operate when an airplane is in flight. This is particularly instructive to students in demonstrating how the Sperry Gyropilot brings a plane back to level flight and true course.

As the plane is completely fitted out with the required vacuum, hydraulic, and electrical systems, the students obtain instrument installation practice along with their instruction and practice in the purely maintenance and overhaul operations.

After students have repaired or overhauled various instruments, those instruments (often an entire panel of flight instruments, or a Sperry Gyropilot and Directional Gyro) are installed in the plane. Then, as the plane is operated to assume various attitudes of flight, the students observe the accuracy of their work. When an instrument fails to operate or read properly the student is faced with the practical problem of trouble shooting.

According to William J. Watkins, Chief Instructor of American School of Aircraft Instruments, there is no other such plane used elsewhere in instrument maintenance training. Use of the plane, declares Mr. Watkins, results in impressing indelibly upon students that instrument accuracy is in direct proportion to care and precision of adjustments and repairs, and provides advance practical experience that could not be obtained otherwise.

Fig. 1. General view of the instrument checking and demonstration plane used at American School of Aircraft Instruments. Mounted and motor-operated to roll, pitch, and yaw, the craft permits observation and checking of instruments after students have repaired or overhauled them. Here one student is operating a motor connected to the tail of the plane, while the other student is watching the instruments.

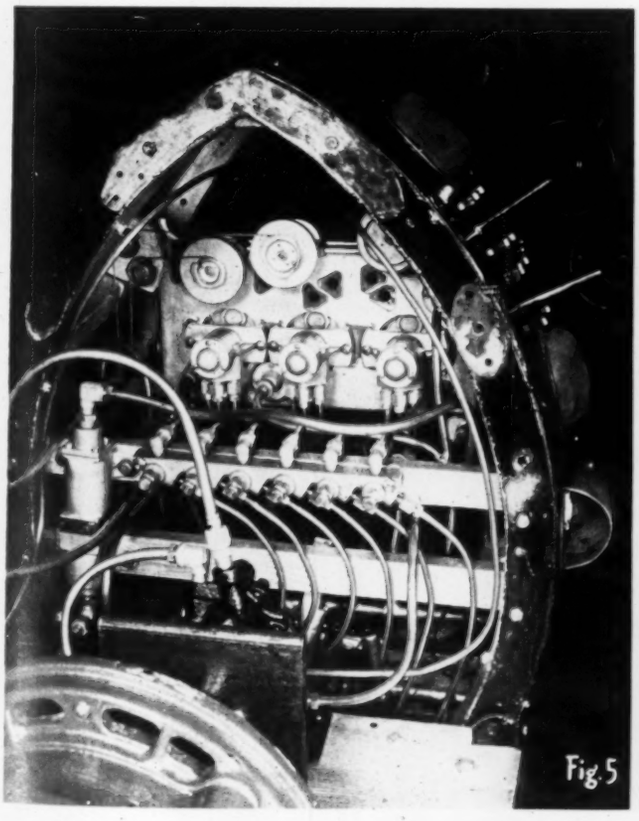
Fig. 2. Motor drive unit for operating the plane. An eccentric rod connects to a drive shaft running through the fuselage, manipulating the craft into banks, climbs, and dives.

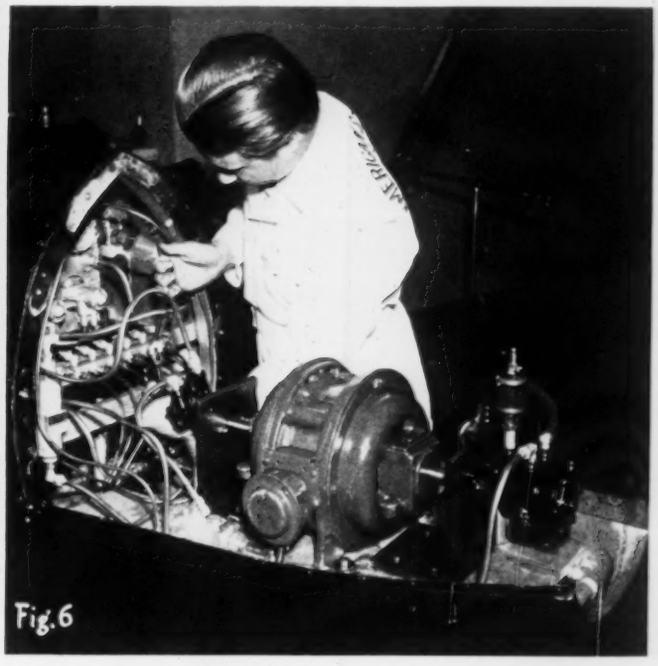
Fig. 3. Showing Sperry Gyropilot installed in the plane. Note that instruments have responded to movement of the craft into a climbing position and bank to the right.

Fig. 4. Showing how a panel of flight instruments can be installed in the plane for observation of operation under flight conditions, and for checking on accuracy after repair, adjustment, or overhaul.

Fig. 5. Close-up of the rear of the Automatic Pilot mounting unit, and a portion of the hydraulic system which operates the controls of the airplane. Just above the maze of tubing are the three balanced oil valves which receive the control signal from the pneumatically balanced air relays seen through the three half-moon openings just above the balanced oil valves. The balanced oil valves relay the control signal hydraulically to the servo-motor system, which in turn operates the rudder, aileron or elevator, whichever may be desired to keep the airplane on its "course." Above the balanced oil valves are the three follow-up pulleys which prevent over-control of the airplane, or hunting. In the foreground to the left is the oil filter for the hydraulic system, and in the foreground at center is the oil pump which supplies the oil pressure required to operate the hydraulic system. Advanced students overhaul, check and install the complete system, which includes the Automatic Pilot, the mounting unit, and the hydraulic system.

Fig. 6. An advanced student is seen connecting the tubing of the hydraulic system of the Automatic Pilot. In the center of the picture is shown the electric motor which drives the vacuum pump, at the right, which supplies the vacuum required to operate the Automatic Pilot. At the left of the motor is seen the oil pump which supplies the oil pressure required to operate the hydraulic system of the Automatic Pilot.





A Simple Tension Jig for Testing Single-riveted and Spot-welded Sheet Specimens

By N. C. PARRISH
Senior Research Assistant, Lockheed Aircraft Corp., Burbank, Calif.

THE TENSION JIG described in this article is suitable for spotwelds, rivets, and similar fastening devices used on sheet stock. Simplicity is the feature of this unit. The screws have been replaced with pins and a slotted tightening ring. The four pins on each end may be tightened by rotation of the take-up ring 90° or less, depending on the sheet stock thickness being used in the test. (See Fig. 1.)

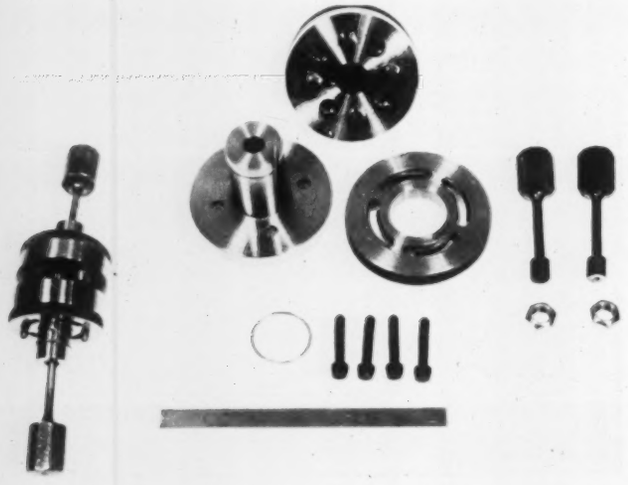


Fig. 1. Showing Jig Parts

A small guide groove in the bottom of each pin prevents misalignment. These pins should not be over 250 Brinell for best performance. The material is not called out for the most part on the drawing (Fig. 2) but it is recommended that X-4130 or 4130 be used and that the heat treat be held at 140,000 to 150,000 tensile strength.

[In the lower right-hand corner of the original drawing there is a complete chart or table of dimensions. It is omitted from Fig. 2 because of reproduction difficulties but full-scale copies can be made available to interested readers engaged in the War Effort. This chart gives the all-out dimensions for each jig and follows the Army method of using the diameter of the rivet as an index to determine the jig size. The maximum tolerances and all allowances are given also.]

As to strength, the critical units are the pins, and they must not be brittle. Drill rod was tried first and found to be unsatisfactory because of brittleness.

The faces of the holders have been reground upon two occasions in order to allow for thicker sheet stock. Therefore, it is suggested that the pin lengths be considered for all standard sheet thicknesses ranging from 0.020" for the small jig to 0.114" for the largest jig. As a rule each jig will accommodate a variation of sheet thicknesses depending upon the depth of the taper slot in the tightening ring. If the pins are made longer than desired, a shim stock washer

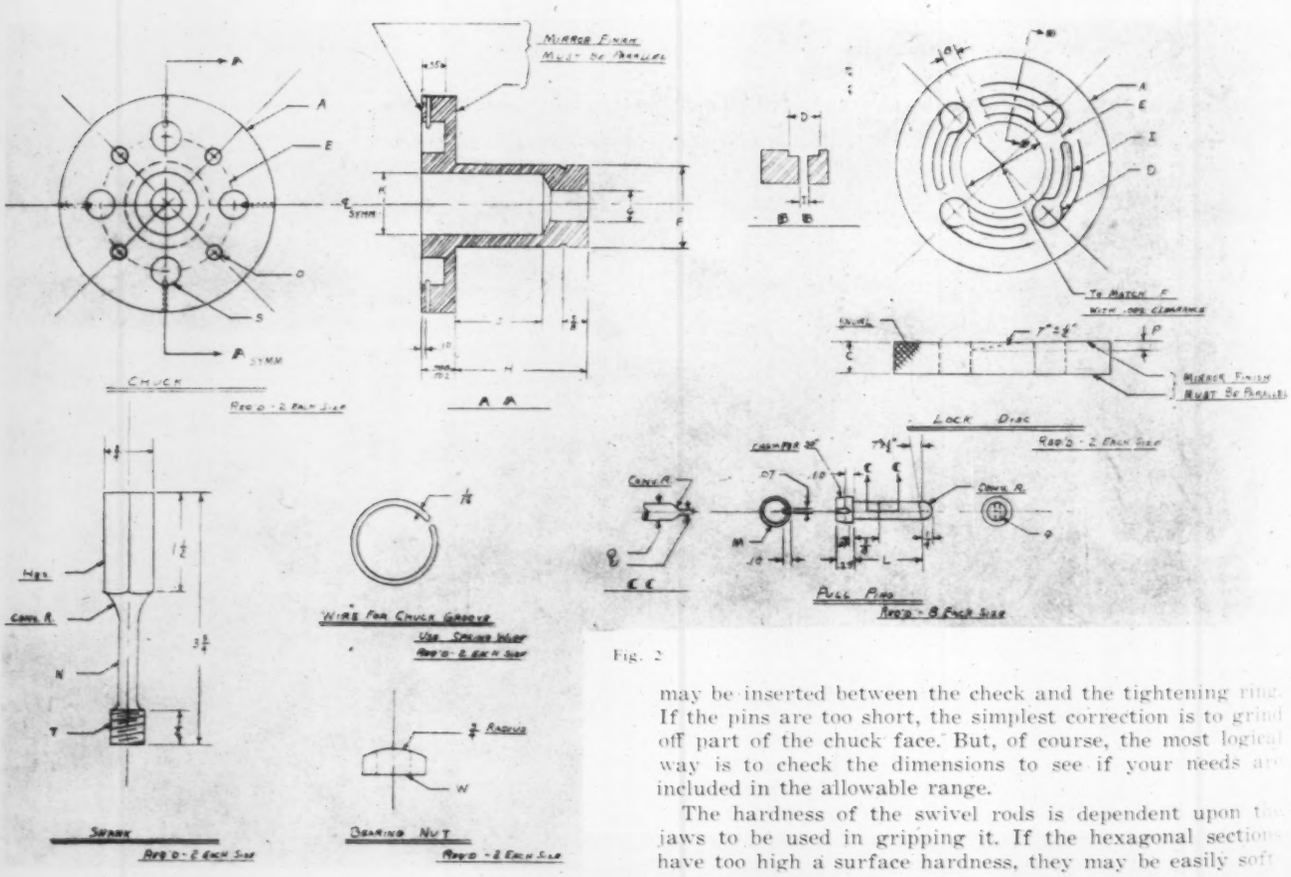


Fig. 2

may be inserted between the check and the tightening ring. If the pins are too short, the simplest correction is to grind off part of the chuck face. But, of course, the most logical way is to check the dimensions to see if your needs are included in the allowable range.

The hardness of the swivel rods is dependent upon the jaws to be used in gripping it. If the hexagonal sections have too high a surface hardness, they may be easily soft

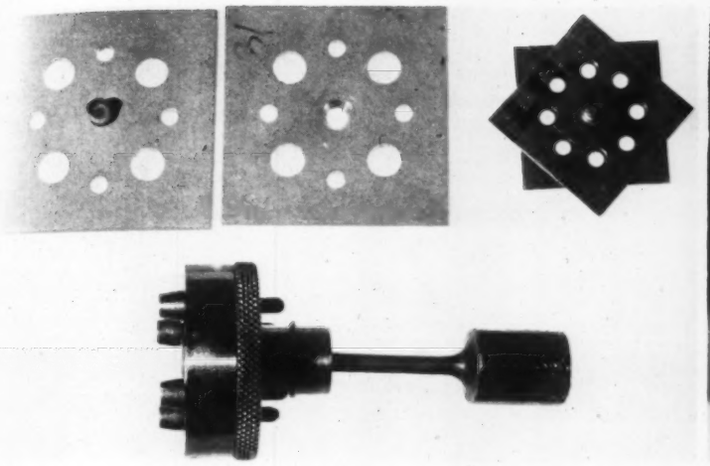


Fig. 3. The larger specimen is a tested unit, the smaller untested unit being for the part of the jig shown.

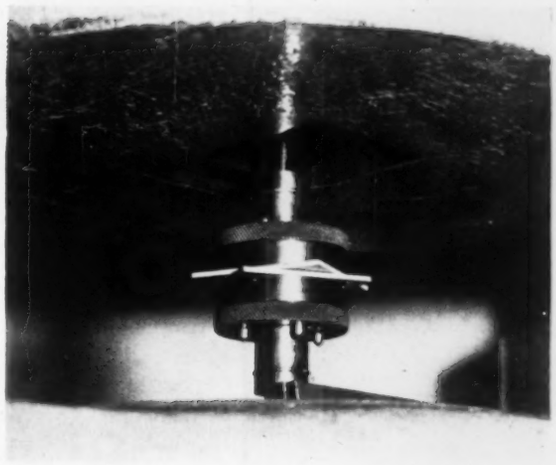


Fig. 4. The completed jig with its component parts being used in testing machine.

ened by annealing without affecting the strength of the jig.

The completed jig is shown in Figs. 3 and 4 with a standard specimen ready for test. Also shown in Fig. 3 (in two parts) is a larger specimen that has been tested.

From practice it has been found helpful to insert small sponge rubber plugs in the stub holes in order to push the pins tight against the specimen and hence make them project as far as possible through the tightening ring.

USEFUL REFERENCE TABLES

AIRSPEED-PRESSURE TABLES

The tables given below are taken in part from those given in NACA Technical Report No. 420 on "Aircraft Speed Instruments" by K. Hilding Beij and in part computed. The differential pressures for a given air speed are standard values used in calibrating Pitot-static airspeed indicators.

The formula used to connect the differential pressure p in inches of water and the indicated air speed V in miles per hour is as follows:

$$p = 407.2\,[(1 + 0.345259 \times 10^{-6}V^2)^{3.5} - 1]$$

where 407.2 inches of water (15°C.) = 29.921 inches of mercury (0°C.) = 1 atmosphere.

See NACA Technical Report 420 for additional details.

Standard Differential Pressure for Air Speeds Measured with a Pitot-static Tube.

Air Speed in MILES PER HOUR

Air Speed		*Differential Pressure*			
mph	ft./sec.	in. water	cm. water	in. mercury	mm. mercury
0	0	0	0	0	0
10	14.7	0.019	0.13	0.0036	0.091
20	29.3	0.197	0.50	0.014	0.37
30	44.0	0.443	1.13	0.033	0.83
40	58.7	0.788	2.00	0.058	1.47
50	73.3	1.231	3.13	0.090	2.30
60	88.0	1.774	4.51	0.130	3.31
70	102.7	2.416	6.14	0.176	4.51
80	117.3	3.158	8.02	0.232	5.89
90	132.0	4.000	10.16	0.294	7.47
100	146.7	4.942	12.55	0.363	9.22
110	161.3	5.985	15.20	0.440	11.2
120	176.0	7.130	18.11	0.524	13.3
130	190.7	8.377	21.28	0.616	15.6
140	205.3	9.726	24.70	0.715	18.2
150	220.0	11.179	28.39	0.821	20.9
160	234.7	12.736	32.35	0.936	23.8
170	249.3	14.399	36.57	1.058	26.9
180	264.0	16.167	41.06	1.188	30.2
190	278.7	18.042	45.83	1.326	33.7
200	293.3	20.025	50.87	1.471	37.4
210	308.0	22.117	56.18	1.625	41.3
220	322.7	24.318	61.77	1.787	45.4
230	337.3	26.630	67.64	1.957	49.7
240	352.0	29.054	73.80	2.135	54.2
250	366.7	31.592	80.25	2.321	59.0
260	381.3	34.245	86.99	2.516	63.9
270	396.0	37.014	94.02	2.720	69.1
280	410.7	39.901	101.35	2.932	74.5
290	425.3	42.907	108.98	3.153	80.1

Air Speed in MILES PER HOUR

Air Speed		*Differential Pressure*			
mph	ft./sec.	in. water	cm. water	in. mercury	mm. mercury
300	440.0	46.03	116.92	3.382	85.9
310	454.7	49.28	125.17	3.621	92.0
320	469.3	52.65	133.74	3.869	98.3
330	484.0	56.15	142.63	4.126	104.8
340	498.7	59.78	151.84	4.393	111.6
350	513.3	63.54	161.37	4.669	118.6
360	528.0	67.42	171.24	4.954	125.8
370	542.7	71.44	181.45	5.249	133.3
380	557.3	75.59	192.00	5.554	141.1
390	572.0	79.88	202.91	5.870	149.1
400	586.7	84.32	214.17	6.196	157.4
410	601.3	88.89	225.79	6.532	165.9
420	616.0	93.61	237.77	6.878	174.7
430	630.7	98.48	250.13	7.236	183.8
440	645.3	103.49	262.87	7.604	193.2
450	660.0	108.66	275.99	7.984	202.8
460	674.7	113.98	289.51	8.375	212.7
470	689.3	119.46	303.43	8.778	223.0
480	704.0	125.10	317.75	9.192	233.5
490	718.7	130.90	332.49	9.619	244.3
500	733.3	136.87	347.65	10.057	255.5
510	748.0	143.00	363.22	10.508	266.9
520	762.7	149.31	379.25	10.971	278.7
530	777.3	155.80	395.73	11.448	290.8
540	792.0	162.46	412.65	11.938	303.2
550	806.7	169.31	430.05	12.441	316.0
560	821.3	176.34	447.90	12.958	329.1
570	836.0	183.56	466.24	13.488	342.6
580	850.7	190.98	485.09	14.033	356.4
590	865.3	198.59	504.42	14.593	370.6
600	880.0	206.40	524.26	15.166	385.2

Standard Differential Pressure for Air Speeds Measured with a Pitot-static Tube

Air Speed in KNOTS

Air Speed		*Differential Pressure*			
Knots	ft./sec.	in. water	cm. water	in. mercury	mm. mercury
0	0	0	0	0	0
10	16.9	.065	.17	.0047	.12
20	33.8	.261	.66	.019	.49
30	50.7	.588	1.49	.043	1.10
40	67.6	1.045	2.65	.077	1.95
50	84.5	1.634	4.15	.120	3.05
60	101.3	2.354	5.98	.173	4.39
70	118.2	3.207	8.14	.236	5.99
80	135.1	4.192	10.65	.308	7.82
90	152.0	5.310	13.49	.390	9.91

Continued on next page

Air Speed		Differential Pressure			
				in.	mm.
Knots	ft./sec.	in. water	cm. water	mercury	mercury
100	168.9	6.563	16.67	.482	12.2
110	185.8	7.951	20.20	.584	14.8
120	202.7	9.475	24.07	.696	17.7
130	219.6	11.136	28.28	.818	20.8
140	236.5	12.935	32.85	.950	24.1
150	253.3	14.873	37.78	1.093	27.8
160	270.2	16.952	43.06	1.246	31.6
170	287.1	19.173	48.70	1.409	35.8
180	304.0	21.538	54.71	1.583	40.2
190	320.9	24.049	61.08	1.767	44.9
200	337.8	26.706	67.83	1.962	49.8
210	354.7	29.512	74.96	2.169	55.1
220	371.6	32.469	82.47	2.386	60.6
230	388.5	35.579	90.37	2.614	66.4
240	405.4	38.844	98.66	2.854	72.5
250	422.2	42.266	107.35	3.106	78.9
260	439.1	45.847	116.45	3.369	85.6
270	456.0	49.591	125.96	3.644	92.6
280	472.9	53.499	135.89	3.931	99.9
290	489.8	57.574	146.24	4.231	107.5
300	506.7	61.820	157.02	4.543	115.4
310	523.6	66.24	168.25	4.867	123.6
320	540.5	70.83	179.92	5.205	132.2
330	557.4	75.61	192.04	5.556	141.1
340	574.2	80.56	204.63	5.920	150.4
350	591.1	85.70	217.69	6.297	160.0
360	608.0	91.03	231.23	6.689	169.9
370	624.9	96.56	245.26	7.095	180.2
380	641.8	102.28	259.79	7.516	190.9
390	658.7	108.20	274.83	7.951	201.9
400	675.6	114.33	290.39	8.401	213.4
410	692.5	120.66	306.48	8.866	225.2
420	709.4	127.21	323.11	9.347	237.4
430	726.3	133.98	340.31	9.845	250.1
440	743.2	140.97	358.06	10.359	263.1
450	760.0	148.18	376.38	10.888	276.6
460	776.9	155.63	395.30	11.436	290.5
470	793.8	163.31	414.81	12.000	304.8
480	810.7	171.24	434.95	12.583	319.6
490	827.6	179.42	455.73	13.184	334.9
500	844.5	187.84	477.11	13.803	350.6
510	861.4	196.53	499.19	14.441	366.8
520	878.3	205.48	521.92	15.099	383.5
530	895.2	214.71	545.36	15.777	400.7
540	912.1	224.21	569.49	16.475	418.5
550	929.0	233.99	594.33	17.194	436.7
560	945.8	245.06	619.91	17.934	455.5
570	962.7	254.44	646.28	18.697	474.9
580	979.6	265.11	673.38	19.481	494.8
590	996.5	276.10	701.29	20.288	515.3
600	1013.4	287.40	730.00	21.118	536.4

U.S. STANDARD ATMOSPHERE

ALTITUDE-PRESSURE-TEMPERATURE TABLE

Altitude	Pressure			Temperature	
Feet	In. Hg	mm. Hg	mb	°C.	°F.
−1000	31.02	787.9	1050.4	+17.0	+62.6
− 500	30.47	773.8	1031.6	16.0	60.8
0	29.921	760.0	1013.2	15.0	59.0
+ 500	29.38	746.4	995.1	14.0	57.2
+1000	28.86	732.9	977.1	13.0	55.4
1500	28.33	719.7	959.5	12.0	53.6
2000	27.82	706.6	942.1	11.0	51.8
2500	27.31	693.8	925.0	10.0	50.0
3000	26.81	681.1	908.1	9.1	48.4
3500	26.32	668.6	891.4	8.1	46.6
4000	25.84	656.3	875.0	7.1	44.8
4500	25.36	644.2	858.9	6.1	43.0
5000	24.89	632.3	843.0	5.1	41.2
5500	24.43	620.6	827.4	4.1	39.4
6000	23.98	609.0	811.9	3.1	37.6
6500	23.53	597.6	796.7	2.1	35.8
7000	23.09	586.4	781.8	1.1	34.0
7500	22.65	575.3	767.0	+0.1	32.2
8000	22.22	564.4	752.5	−0.8	30.6
8500	21.80	553.7	738.2	−1.8	28.8
9000	21.38	543.2	724.2	−2.8	27.0
9500	20.98	532.8	710.3	−3.8	25.2
10000	20.58	522.6	696.7	−4.8	23.4
10500	20.18	512.5	683.3	−5.8	21.6
11000	19.79	502.6	670.1	−6.8	19.8
11500	19.40	492.8	657.0	−7.8	18.0
12000	19.03	483.3	644.3	−8.8	16.2
12500	18.65	473.8	631.7	−9.8	14.4
13000	18.29	464.5	619.3	−10.8	12.6
13500	17.93	455.4	607.1	−11.7	10.9
14000	17.57	446.4	595.1	−12.7	9.1
14500	17.22	437.5	583.3	−13.7	7.3
15000	16.88	428.8	571.7	−14.7	5.5
15500	16.54	420.2	560.2	−15.7	3.7
16000	16.21	411.8	549.0	−16.7	1.9
16500	15.89	403.5	538.0	−17.7	+0.9
17000	15.56	395.3	527.0	−18.7	−1.7
17500	15.25	387.3	516.4	−19.7	−3.5
18000	14.94	379.4	505.8	−20.7	−5.3
18500	14.63	371.7	495.6	−21.7	−7.1
19000	14.33	364.0	485.3	−22.6	−8.7
19500	14.04	356.5	475.3	−23.6	−10.5
20000	13.75	349.1	465.4	−24.6	−12.3
20500	13.46	341.9	455.8	−25.6	−14.1
21000	13.18	334.7	446.2	−26.6	−15.9
21500	12.90	327.7	436.9	−27.6	−17.7
22000	12.63	320.8	427.7	−28.6	−19.5
22500	12.36	314.1	418.8	−29.6	−21.3
23000	12.10	307.4	409.8	−30.6	−23.1
23500	11.84	300.9	401.2	−31.6	−24.9
24000	11.59	294.4	392.5	−32.5	−26.5
24500	11.34	288.1	384.1	−33.5	−28.3
25000	11.10	281.9	375.8	−34.5	−30.1
25500	10.86	275.8	367.7	−35.5	−31.9
26000	10.62	269.8	359.7	−36.5	−33.7
26500	10.39	263.9	351.8	−37.5	−35.5
27000	10.16	258.1	344.1	−38.5	−37.3
27500	9.94	252.5	336.6	−39.5	−39.1
28000	9.72	246.9	329.2	−40.5	−40.9
28500	9.50	241.4	321.8	−41.5	−42.7
29000	9.29	236.0	314.6	−42.5	−44.5
29500	9.08	230.7	307.6	−43.4	−46.1
30000	8.88	225.6	300.8	−44.4	−47.9
30500	8.68	220.5	294.0	−45.4	−49.7
31000	8.48	215.5	287.3	−46.4	−51.5
31500	8.29	210.6	280.8	−47.4	−53.3
32000	8.10	205.8	274.4	−48.4	−55.1
32500	7.91	201.0	268.0	−49.4	−56.9
33000	7.73	196.4	261.8	−50.4	−58.7
33500	7.55	191.8	255.7	−51.4	−60.5
34000	7.38	187.4	249.8	−52.4	−62.3
34500	7.20	183.0	244.0	−53.4	−64.1
35000	7.04	178.7	238.2	−54.3	−65.7
35332	6.93	175.9	234.5	−55.0	−67.0
35500	6.87	174.5	232.6	−55.0	−67.0
36000	6.71	170.4	227.2	−55.0	−67.0
36500	6.55	166.4	221.8	−55.0	−67.0
37000	6.39	162.4	216.5	−55.0	−67.0
37500	6.24	158.6	211.4	−55.0	−67.0
38000	6.10	154.9	206.5	−55.0	−67.0
38500	5.95	151.2	201.6	−55.0	−67.0
39000	5.81	147.6	196.8	−55.0	−67.0
39500	5.68	144.1	192.1	−55.0	−67.0
40000	5.54	140.7	187.6	−55.0	−67.0
40500	5.41	137.4	183.2	−55.0	−67.0
41000	5.28	134.2	178.9	−55.0	−67.0
41500	5.16	131.0	174.7	−55.0	−67.0
42000	5.04	127.9	170.5	−55.0	−67.0
42500	4.92	124.9	166.5	−55.0	−67.0
43000	4.80	122.0	162.7	−55.0	−67.0
43500	4.69	119.1	158.8	−55.0	−67.0
44000	4.58	116.3	155.1	−55.0	−67.0
44500	4.47	113.5	151.3	−55.0	−67.0
45000	4.36	110.8	147.7	−55.0	−67.0
45500	4.26	108.2	147.3	−55.0	−67.0
46000	4.16	105.7	140.9	−55.0	−67.0
46500	4.06	103.2	137.6	−55.0	−67.0
47000	3.97	100.7	134.3	−55.0	−67.0
47500	3.873	98.38	131.1	−55.0	−67.0
48000	3.781	96.05	128.0	−55.0	−67.0
48500	3.693	93.79	124.9	−55.0	−67.0
49000	3.605	91.57	122.0	−55.0	−67.0
49500	3.520	89.41	119.2	−55.0	−67.0
50000	3.436	87.30	116.4	−55.0	−67.0
51000	3.276	83.22	110.9	−55	−67
52000	3.124	79.34	105.7	−55	−67
53000	2.978	75.64	100.8	−55	−67
54000	2.839	72.12	96.13	−55	−67
55000	2.707	68.76	91.59	−55	−67
56000	2.581	65.55	87.33	−55	−67
57000	2.460	62.49	83.19	−55	−67
58000	2.346	59.58	79.33	−55	−67
59000	2.236	56.80	75.73	−55	−67
60000	2.132	54.15	72.13	−55	−67
61000	2.033	51.63	68.79	−55	−67
62000	1.938	49.22	65.59	−55	−67
63000	1.847	46.92	62.52	−55	−67
64000	1.761	44.73	59.59	−55	−67
65000	1.679	42.65	56.80	−55	−67
66000	1.601	40.66	54.13	−55	−67
67000	1.526	38.76	51.60	−55	−67
68000	1.455	36.95	49.20	−55	−67
69000	1.387	35.23	46.93	−55	−67
70000	1.322	33.59	44.66	−55	−67
71000	1.261	32.02	42.66	−55	−67
72000	1.202	30.53	40.66	−55	−67
73000	1.146	29.10	38.80	−55	−67
74000	1.093	27.75	36.93	−55	−67
75000	1.041	26.45	35.20	−55	−67
76000	0.993	25.22	33.60	−55	−67
77000	0.946	24.04	32.05	−55	−67
78000	0.902	22.92	30.53	−55	−67
79000	0.860	21.85	29.06	−55	−67
80000	0.820	20.83	27.73	−55	−67

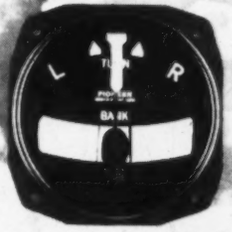
For more complete tables and formulas, see N.A.C.A. Technical Report No. 538.

FOR VICTORY!

—his eyes must be sharp as his claws

Pioneer Sensitive Altimeter

Pioneer Air Speed Indicator



Pioneer Turn and Bank Indicator

Pioneer Sensitive Rate-of-Climb Indicator

Pioneer Remote Indicating Magnesyn Compass

INSTRUMENTS of utmost sensitivity and reliability are necessary to gain maximum effectiveness from an airplane's range, speed and fire-power. A split-second advantage can be priceless. Implicit confidence can snatch Victory from defeat. The keen realization of these truths by Pioneer craftsmen has made and has kept the precision standards of Pioneer Aircraft Instruments extremely high.

Pioneer INSTRUMENT

DIVISION OF BENDIX AVIATION CORPORATION

BENDIX, NEW JERSEY, U. S. A.

What Are AERONAUTIC Instruments?

As explained on the first page of this Department, the kingdom of *aviation* instruments is practically limitless. In this kingdom, the province of most direct interest to the readers of this department is that of *aeronautic* instruments. What are the boundaries of this province?

Trying to answer this question, I had used up dozens of sheets of paper without getting anywhere, until recollection of a previous experience* convinced me that the question really is: "*Which are the aeronautic instruments?*"

Recollection of that previous experience convinced me, furthermore, that the specific question should be: "Which are the aeronautic instruments *today!*" The most authoritative answer at any particular time is the latest list made up by a man whose job for about twenty years has been to "govern" the province of aeronautic instruments. He used to make up such lists every three or four years . . . and each list was about 20 percent longer than the preceding one. Several weeks ago I saw him and, planning for this Aviation Instruments department of *Instruments*, I asked him whether he had a 1942 (or late 1941) official list of aeronautic instruments prepared and ready for publication. He had not. He explained that there was little likelihood of any "official" list of aeronautic instruments being prepared in 1942 and he added that there was an even smaller likelihood of his being able to find time to do the necessary research and arrangement personally, even if the government Department with which he is connected decided that the work should be done.

That was a disappointment! But it was followed by a stroke of good luck a couple of days ago (May 29 to be exact) when I invited this friend again: as part of his official duties he was to lecture on Aeronautic Instrumentation before the [censored] although his lecture was not to be released for publication, there was no restriction on the topical outline of this lecture so that my visitor was welcome to an extra carbon copy. However, he insisted that if I published his outline I should make it clear to our readers that:—

(1) This is not THE list of the aeronautic instruments but merely a classification.

(2) Even as a classification it is not official. It has not been approved by any government Department and will not be submitted for approval in its present form.

(3) This classification is not the work of a committee or Board, but of one individual.

(4) It is not a scientific or rational classification but merely a convenient guide—specifically a lecturer's memory-aid. The lecturer himself considers it far from perfect.

Well, I've kept my promise and printed these four modest reservations, but I can't refrain from asserting that this is an INSTRUCTIVE classification. No matter how "far from perfect" it may be, it is USEFUL and TIMELY. It is better than the classifications in even the most recent textbooks and it will help win the war because it will suggest to thousands of *Instruments* readers various specific lines of studies, research, or direct War Effort work.

—MFH

*"Which Are The Industrial Instruments?" **Instruments**, Vol. 3, No. 11, Nov. 1930, pages 655-658.

GENERAL CLASSIFICATION

1. *Navigation instruments.*
2. *Power plant instruments.*
3. *Miscellaneous instruments.*
4. *Oxygen instruments.*
5. *Communications.*
6. *Airship instruments, special.*
7. *Aerial photography apparatus.*
8. *Special flight test instruments.*
9. *Airport instruments.*
10. *Laboratory test apparatus.*

1. Navigation Instruments

Determination of Position
- Maps and Landmarks
- Dead Reckoning
- Octant or Sextant
- Radio Marker Beacons
- Radio Triangulation
- Chronometer

Direction of Flight
- Magnetic Compass
- Turn and Bank Indicator
- Drift Meter
- Radio Beam
- Radio Compass
- Directional Gyro
- *Gyromagnetic Compass

Speed
- (1) For Indicated A.S.
  - Pitot-static Airspeed Indicator
- (2) For True A.S.
  - Pitot-static Airspeed Indicator
  - Air Thermometer
  - Altimeter
- (3) For Ground Speed
  - As in (2) and Driftmeter

Altitude
- Aneroid Altimeter
- *Radio and Sonic Altimeters
- Rate-of-climb Indicator

Attitude of Airplane
- Gyro Horizon

**Instrument Landing Systems*
- Position: Radio Marker Beacons
- Direction:
  - Horizontal: Radio Beam
  - Vertical: Curved Radio Beam or Keyed Radio Beam or None
- Altitude: Aneroid Altimeter, Rate-of-Climb Indicator
- Attitude: Gyroscopic Horizon

Controllers
- Automatic Pilot Controls: Direction, Altitude, Attitude.
- *Automatic Landing System Controls: Direction, Air Speed, Rate of Descent, Altitude, Attitude, Wheel Brakes.

*Experimental

**Flight Analyzers*
- Altitude
- Air Speed
- Acceleration, vertical
- Engine Speed
- Oil Temperature
- Oil Pressure
- Manifold Pressure
- On-off of gyro pilot, radio, etc.

Auxiliary
- Suction gage for gyro instrument.
- Pressure gage for automatic pilot.

**Air lines only

2. Power Plant Instruments

Engine Speed
- Tachometer, electric
- Tachometer, shaft driven
- Synchroscopes
- Torque meter

Engine Temperature
- Oil thermometer
- Cylinder head thermometer
- Carburetor mixture thermometer

Pressure
- Fuel pressure gage
- Oil pressure gage
- Manifold pressure gage

Fuel Instruments
- Fuel quantity gage
- Flowmeter

Engine Gage Unit

Fuel-air Ratio Indicator

3. Miscellaneous Instruments

- Flap position indicators
- Wheel position indicators
- Deicer pressure gage
- Ammeter, power supply
- Voltmeter, power supply
- Free air thermometer
- Accelerometer
- CO indicators
- Clock

4. Oxygen Instruments

Gaseous Oxygen
- Continuous flow apparatus
- Demand apparatus
- Rebreathers

**Liquid Oxygen Apparatus*
- as for gaseous

*Experimental

5. Communications

- Radio
- Inter plane communication

6. Airship Instruments, Special

- Superheat meters
- Air speed indicators
- Lift balance

7. Aerial Photography Apparatus and Instruments

- Camera, etc.
- Altimeter

8. Special Flight Test Instruments

- Barograph
- Thermograph
- Stop clock
- Angle of attack indicators
- Recording accelerometers
- CO indicators
- Engine speed recorders
- Free air thermometers
- V-G recorders
- Stick force indicators
- Strain gages

9. Airport Instruments

- Communications apparatus
- Anemometers
- Wind direction instruments
- Barometer
- Hydrograph
- Visibility meter
- Cloud height meter
- C-G computer
- Radio sonde

ROUGH CLASSIFICATION OF TYPES OF MECHANISMS

Mechanical	*Electrical*
Octant or sextant	Radio altimeter
Chronometer	Sonic altimeter
Clock	Fuel air ratio indicators
Compass	Position indicator
Turn and bank indicator	Free air thermometers
Drift meter	CO indicators
Gyro horizon	Radio equipment
Directional gyro	Superheat meters
Gyro magnetic compass	Thermograph
Airspeed indicators	Strain gages
Altimeter, aneroid	Wind direction instruments
Rate-of-climb indicator	Cloud height meter
Manifold pressure gages	
Fuel quantity gages	
Torque meter	
Pressure gages, most	
Accelerometers	
Oxygen apparatus	
Barograph	
V-G recorders	
Stick force indicators	
Barometer	

Instruments either Mechanical or Electrical Types or Combination of both
- Compass, distant indicating
- Free air thermometers
- Engine thermometers
- Tachometers
- Fuel and oil pressure gages
- Flowmeter
- Recording accelerometers
- Anemometers
- Hygrometers
- Radio sonde

WEATHER

CAN YOUR INSTRUMENTS TAKE IT?

IF THEY FLY TO WAR THEY MUST CONTINUE THEIR ACCURACY IN FACE OF:

- **COLD** • 100° BELOW ZERO
- **HEAT** • TROPICAL SUN
- **MOISTURE** • STEAM • SLEET • SALT AIR
- **MAGNETIC STORMS**
- **VIBRATION**

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Old and Odd Aircraft Instruments—I

THERE are more museums and collections in Washington than you will find listed in tourists' guides, in W. M. Kiplinger's "Washington Is *Like* That" or even in the monumental (5½-lb.) "Washington, City and Capital" produced by the Federal Writers Project. In particular, there are so many collections of old and odd aircraft instruments in governmental, semi-official and private institutions that an illustrated guide could be published about them alone. At any rate, I came to believe that these old and odd aircraft instruments possess immediate educational value in the War Effort. I wanted to borrow the most seductive ones so as to take them to classrooms and have students inspect them. No could do! So, instead of "bringing 'em back alive" from Washington, I brought back photographs—which was a better thing to do anyway, because it enables ALL readers to have a fairly close look. —MFB

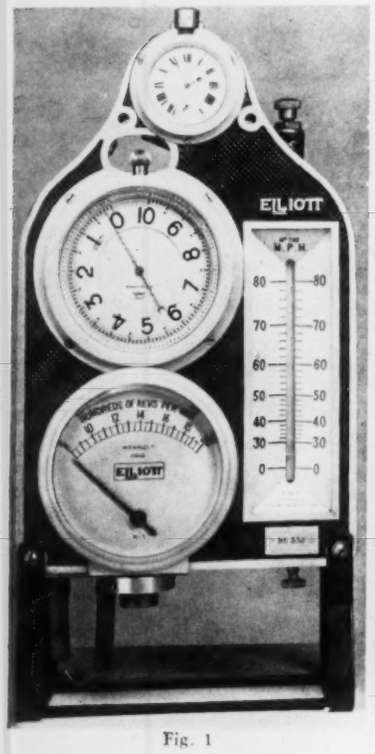


Fig. 1

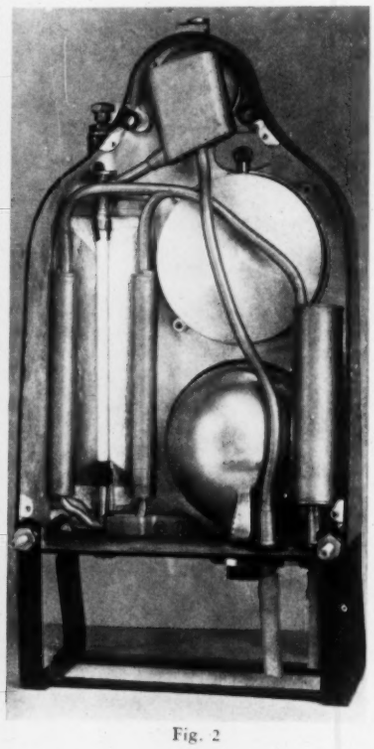


Fig. 2

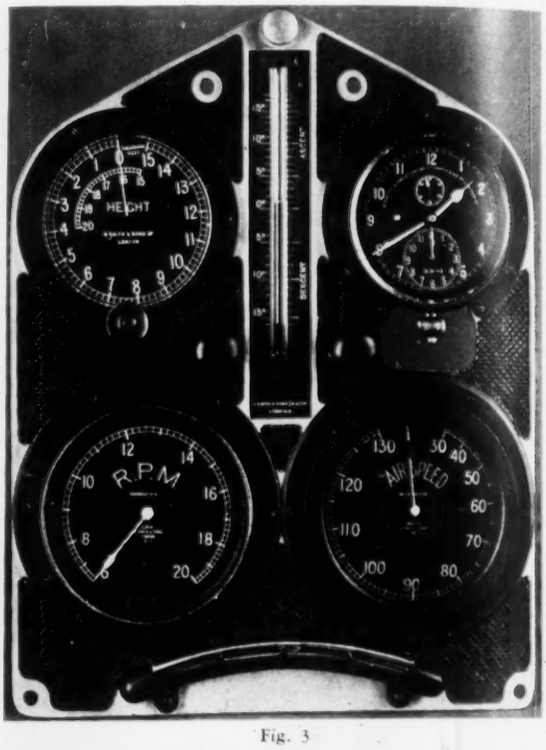


Fig. 3

Figs. 1 and 2 are the front and rear views of the Elliott Bros. instrument board in use by the British about the year 1915. This instrument board contains an 8-day clock, a 10,000-ft. Short & Mason "Tycos" altimeter, a Renault tachometer and a Pitot-static air speed indicator of the liquid indicator type. Weight 7 lbs. 5 oz.

Fig. 3 is the front view of the S. Smith and Sons, Ltd. (British) instrument board used during early part of First World War. The six instruments are: altimeter with additional "sensitive" scale for altitudes between 1500 and 2000 feet; clock with elapsed-time feature; tachometer; air-speed indicator; inclinometer; bank indicator. All instruments (even the clock) bear the name of S. Smith & Sons and no other manufacturer's name. Total weight, 14 lbs.

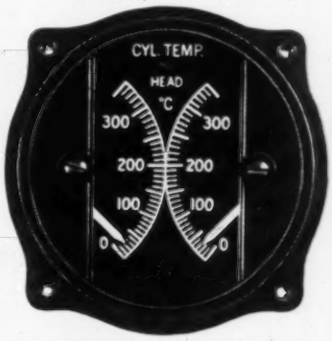
Fig. 4 shows an Italian navigational instrument used for steering by stars. Being a simple rotating planisphere, it is accurate only in one latitude—in this particular case the latitude of Northern Italy—or of Maine, Minnesota or Oregon. To use it the pilot sets the time-of-day (solar) against the solar-year-date on the outer circular scales, then he followed the curved guide lines toward the center to the nearest bright star. The closer any star was to the horizon, the closer he could read its azimuth. The instrument had been knocked about before the photograph was taken, and the photograph itself does not show fine details, but by looking closely you may perhaps be able to see that at midnight of February 20-21, if you want to steer a 135° course you should head straight for Sirius.

Fig. 4

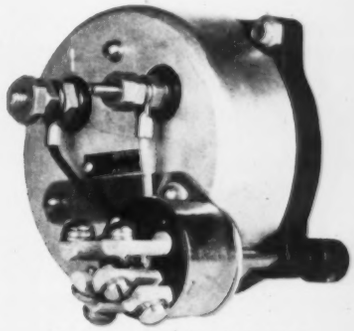
ENGINE CYLINDER TEMPERATURE INDICATORS—THERMOCOUPLE TYPE

(Write for Bulletin 1-2)

Single Indicator Part 17AT



Dual Indicator Part 96AT



Part 17AT with 98 Switch

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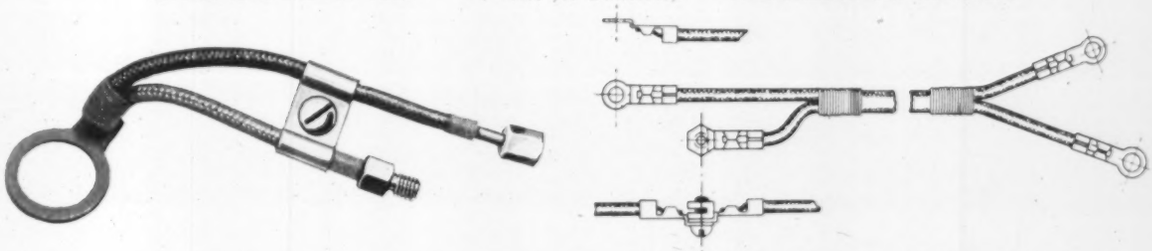

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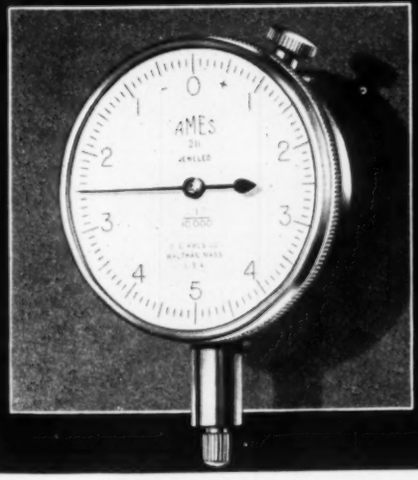

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(Continued from Page 205)

aluminum damping vane, the three phosphor-bronze conducting springs and the pointer assembly (with three cross-arms and balance nuts). Gaskets under the sub-base and between the cover and the base make the instrument dust-proof. The cover is held to the base by screws, the base being tapped.

The single-phase and three-phase instruments differ only in the connection of the moving coils, the external resistance and the fact that the three-phase instrument has an inter-

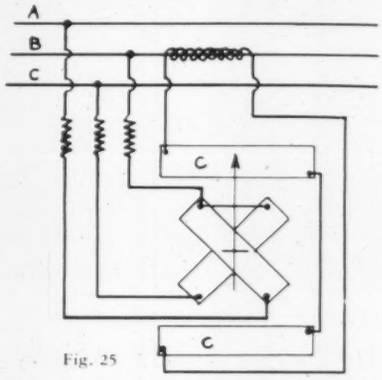


Fig. 25

nal resistor spool in the middle leg of the voltage circuit. The coil connections of the electrodynamic type power factor meters are as shown in Figs. 25 and 26. It will be noted that the three-phase instrument makes use of an external

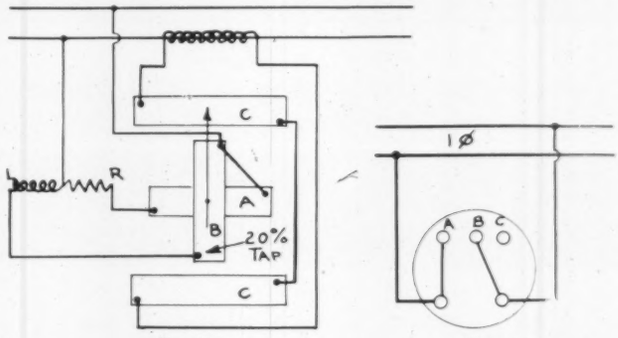


Fig. 26 Fig. 27

resistor in each of the outside legs of the voltage circuit while the single-phase instrument has a resistor-reactor connected as shown in Fig. 26. The pointer position of the single and three-phase meters are also different as shown in Figs. 25 and 26.

Principle of Operation

The single-phase and polyphase electrodynamic instruments operate the same way, except that the single-phase instrument has its moving coils connected through a resistor-reactor across the line to obtain its rotating field. Fig. 26 shows the single-phase instrument connections.

The arrangement of the coils is the same as that of a wattmeter except that there are two moving coils A and B connected through an inductance and resistance as shown in Fig. 26. The deflecting coil B is tapped so that 20% of the two coils is in series with the resistance R and 80% in series with the inductance L. The resultant current of the 80% and the 20% winding is approximately 90° out of phase with the current in the holding coil A. This is due to the fact that current of the 20% winding of the deflecting coils is reversed with respect to that of the holding coil A. Under this condition the reaction between the stationary coils CC and B will be a minimum at unity power factor. The torque exerted on A will cause the moving system to take a position of minimum torque where the plane of A and that of CC will be parallel. At zero power factor the

coil will assume a position parallel to CC exerting all the torque and causing coil A to be at right angles to the plane of CC. Theoretically the readings will be affected by frequency because the current in the reactor changes with frequency variations.

The three-phase power factor meter of the electrodynamic type has two moving coils mounted at right angles to each other and connected as shown in Fig. 25. The voltage is connected to these coils through conducting springs of extremely low torque, so that no mechanical influence is exerted. The stationary coils CC of Fig. 25 are the current coils through which the load current passes. Fig. 25 also shows the series resistors used in the two outside legs of the voltage circuit and the internal resistance in the center leg. The moving coils are connected in such a manner that the current in one coil lags and the current in the other leads the load current by 30°, the natural phase difference of a three-phase line at unity power factor. Under these conditions, at unity power factor the moving system will assume a position where the two coils are acted upon equally by the field of load current. When this balance is had, each moving coil will have an angle of 45° with respect to the stationary coil and the pointer will rest at unity or 100% power factor on the scale. At other than unity power factor one of the coils will be nearer in phase with the load current and will tend to line up with the stationary coil, causing the pointer to assume a new position. The inductance of the power factor meter is so low that frequency does not affect its reading. Changes of load current act upon both moving coils with the same force, therefore the deflection of the pointer is not affected by load variations unless the current falls below 40% of coil rating.

Test and Inspection.

Before testing either the single-phase or polyphase power factor meter a ground test of 1500 volts between coil terminals and ground (base), and 1500 volts between potential and current terminals is applied.

A mechanical inspection follows the ground test. This inspection is for the purpose of insuring the instrument against loose connections, poor soldering, friction, loose nuts and screws, improper end play, old parts, etc. The instrument is then balanced so that the pointer will stay put at any point on the scale.

The instrument is next given a polarity test to ascertain if it is properly wired. Approximately 20 volts are applied to the instrument in this test after being connected as shown in Fig. 27. This test should result in the pointer assuming a position at 100% power factor on the single-phase meter and approximately 50% lagging power factor on the three-phase meter.

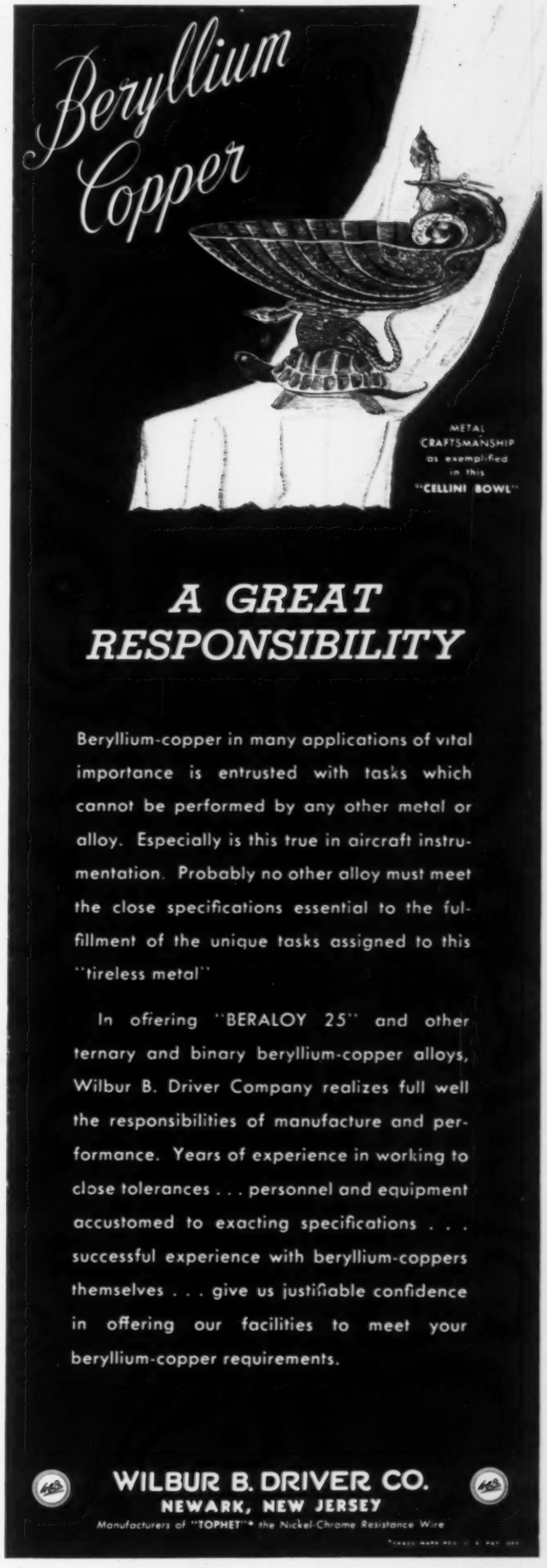
Figs. 25 and 26 show the instruments connected to a test circuit. The 25- or 60-cycle tap on the reactor used with the single-phase meter should be connected according to the application. With a suitable standard of comparison the scale length and distribution may be checked. The scale length of the three-phase meter is varied by changing the internal resistance in the middle leg of the potential circuit, while the same results are obtained in the external reactor of the single-phase instrument. Moving the pointer with respect to the moving coils in either the single-phase or three-phase meter will correct scale distribution in cases where the scale is high on one side and low on the other.

When the instrument is calibrated and the dial marked, the name plates on the external resistors or reactor should be marked to identify them with the instrument.

The instrument is next cleaned and given an electrical inspection, after which it is again ground tested before being installed and connected as explained in the following paragraphs.

Installing and Connecting.

The line connections of power factor meters can best be explained diagramatically as in Figs. 28 and 29, which are largely self-explanatory.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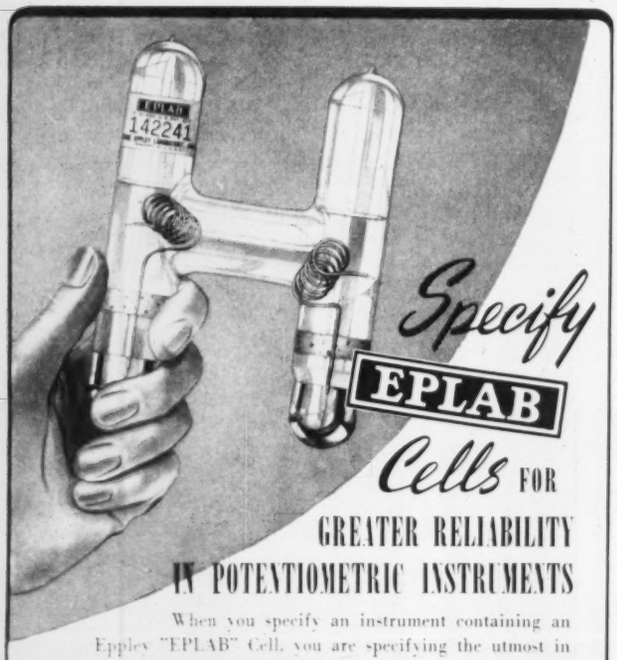

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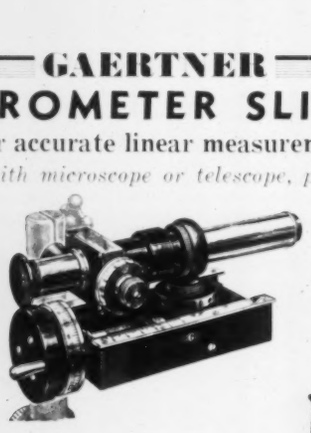

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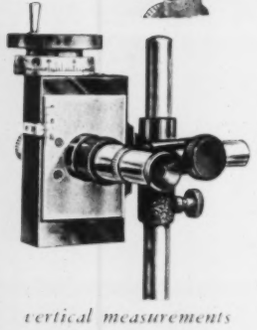

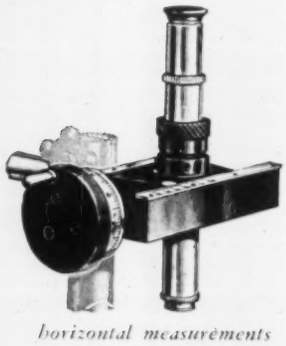

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As with other electrical indicating instruments, the power factor meter will not stand excessive vibration or shocks which would damage the pivots and jewels. In view of the foregoing it is suggested that as much work and wiring as possible be done on the switchboard before mounting the instruments.

Before making permanent connections to the power factor meter, be sure to read all information supplied by the manufacturer to avoid misapplication, wrong connections, failure to use auxiliary equipment, etc. The line should be

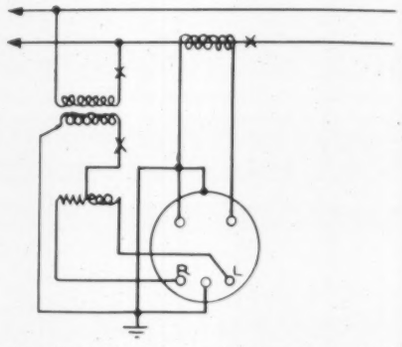

Fig. 28. Single-phase power factor meter connections.

pre-checked to be sure the voltage and current are within the capacity range of the instrument. Where current or potential transformers are used, the case of the instrument should be connected to the grounded side of the secondary circuit of the transformer.

After connections are made, a check should be made to ascertain if the connections are correct as regards proper sequence of voltages and relative polarities of current and

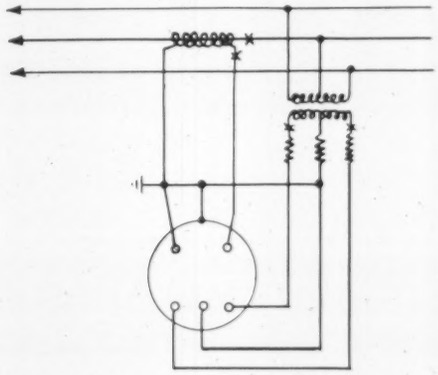

Fig. 29. Three-phase three-wire power factor meter connections.

potential coils. If the moving element tends to move so that the pointer is held hard against the bumper at one end of the scale, the current leads should be reversed to correct the polarity. In 360° scale power factor meters, the pointer will indicate 180° away from the actual power factor of the line. This indication may also be corrected by reversing the current leads. If the current transformer is in the wrong place, the pointer will indicate an angular error of 60° or 120°.

When making the potential connections to a polyphase power factor meter, if the phase sequence of a three-phase three-wire circuit is not known, the following test will be a guide in making correct connections. With current and potential applied to the instrument, shunt the current terminals with a low-resistance wire. If, with this connection, the pointer moves to the lag side, the connections are correct. If the pointer moves to the lead side, the connections are incorrect and can be corrected by interchanging the two outside potential leads to the instrument.

When connecting power factor meters to a circuit through transformers, be sure to select the proper transformer ratio so that the current circuit is energized to at least 10% of its rated capacity and the potential circuit is between 75

of the rated voltage of the instrument. With current potential applied as stated, the instrument will operate at its highest accuracy.

POSSIBLE MECHANICAL AND ELECTRICAL TROUBLES

Due being weaker in power factor meters than in most other industrial electrical instruments, "small" causes may have relatively large effects. For this and other reasons, power factor meters have the reputation of being more delicate than other instruments. During the last fifteen to twenty years, a larger proportion of power factor meters have been returned to manufacturers' factories for calibration and repairs than any other class of instruments in general use. Experience with these returned instrument has shown that many users hesitated to make simple inspections and adjustments.

Friction or sticking.

When friction or sticking manifests itself in a power factor meter, the instrument should be given a visual inspection to ascertain if all the visible moving parts have ample clearance. Lint, dirt or other foreign particles that find their way in the gaps between the moving and stationary parts of the instrument should be removed to avoid frictional troubles. A few points to check before dismantling an instrument to correct friction are: *clearance* between scale and pointer, damping disk and magnet, moving coils and stationary coils, element shaft, balance arm; also spring convolutions and spring position with respect to adjacent parts.

If the pointer sticks at either end of the scale, check to see if the pointer is caught on the bumpers.

If the trouble is not found in this visual inspection, check the element end-play to ascertain that the element has sufficient end-to-end motion (not tight between the jewels and not so loose that the moving parts touch their adjacent stationary parts). If an adjustment of end play is necessary, follow the instructions outlined in Chapter I.* Dirt in the jewels or on the pivots will also cause friction and should be carefully guarded against when dismantling or reassembling an instrument.

Balance.

Power factor meters, like frequency meters, are balanced so that when the instrument is not energized, the pointer will remain at any point on the scale it is placed. From this it will be obvious that any unbalancing of the element will affect the calibration of the instrument. Element unbalance may be caused by parts loosening and shifting, distortion of moving coils, charring of coils (part of insulation burned off coils due to overload), bent pointer or balance arms, or balance weights becoming detached.

Some makes of the moving-iron type power factor meters are balanced by moving weights along balance arms while others are balanced by applying paint on the damping disk. Paint should be applied to various spots around the disk and allowed to dry after each application. The process of applying the paint to different parts of the disk should continue until the pointer shows no tendency to rotate when the instrument is deenergized. A perfectly balanced power factor meter will be much more accurate on low currents than an instrument that is not correctly balanced. This is due to the fact that as the current is reduced, the torque of the instrument is lowered, and the mechanical torque due to unbalance causes an appreciable error. Power factor meters of the electrodynamic type are practically all balanced by the cross-arm and weight method as outlined in Chapter I.

It often is possible to correct small errors of calibration by changing the balance of the element. For example, if the power factor indication is high on both the lag and lead side, the tail weight should be reduced. If the indication is low on both sides, the tail weight should be increased. A high reading on the lead side, with a like amount low on the lag side, may be corrected by increasing the weight on

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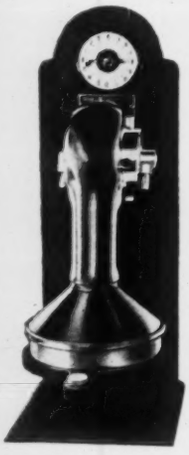

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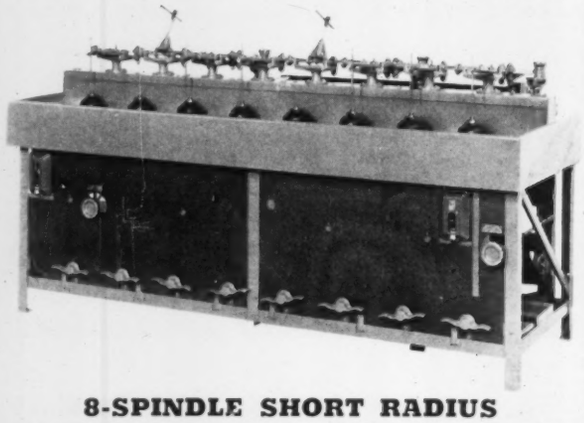

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the right cross-arm or decreasing the weight on the left cross-arm. Decreasing the weight on the right arm and increasing the weight on the left arm will correct small errors when the indication is low on the lead side and high on the lag side. Be sure the balance weights are tight after adjustments are made so that they will not shift.

Electrical Errors.

Electrical errors are of two classes, those that cause complete lack of instrument operation, and those that cause incorrect indications.

Incorrect phase rotation, polarity and wrong connections have been covered earlier under "Installing and Connecting." Other external points to check when a power factor meter fails to operate or operates incorrectly, are loose connections, fuses, switches and transformer settings.

Complete Lack of Indication.—When a power factor meter fails to indicate and the fault is not in the line, one of the following possible defects may exist.

(1) The current coil or the leads from the terminals to the coil may be open.

(2) Both sides of the split-phase circuit (resistance-reactance) of the single-phase instrument or two of the series resistors of the three-phase instrument may be open.

(3) A shorted current coil would also cause failure of indication.

These conditions can be detected by the use of an ohmmeter or with an ammeter and a voltmeter. An ohmmeter check across each part will indicate directly if the particular part is open or shorted. If the instrument is connected in a live circuit an ammeter in series or parallel with the current coil will indicate the condition (open or short) of the various parts of the circuit.

An open or shorted current coil will be detected by connecting an ammeter first in series and then in parallel with the current coil. When in series with the current coil, the ammeter will not indicate if the current coil is open but will indicate if the coil is shorted. When an ammeter is connected in parallel with the current coil, it will show an indication if the current coil is open, but will fail to indicate if the current coil is shorted.

If both sides of the potential circuit of a single-phase instrument are open, the trouble may be due to open coils, open resistor and reactor, open in the common lead connections, or a combination of the three. A visual inspection, or checking each connecting wire end-to-end with a clip lead, will reveal connecting lead troubles. A voltmeter check across each part of the circuit will show which parts are faulty. With the voltmeter connected across the resistor or the reactor, the voltmeter will indicate if the coils are not open but will fail to indicate if the coils are open. By connecting the voltmeter across each coil, a voltmeter indication means that the resistor or reactor is not open, while a lack of indication of the voltmeter means that the resistor or reactor is open. Shorted coils, resistors, or reactors, will be known by a lack of voltage indication when a voltmeter is connected across the faulty part.

Open or shorted coils or series resistors of the three-phase power factor meter may be checked as outlined for the single-phase power factor meter.

When making instrument checks on live current circuits, it should be kept in mind that a high voltage build-up may exist where a coil is open. This is due to the fact that an open in the series circuit means that the secondary of the current transformer is open, a condition that might cause damage to the instrument or personal injury to the one checking the same.

Incorrect Indication.—When a power factor meter reads incorrectly, it may be due to any of the following causes:

(1) Low voltage or current reduces the torque of the instrument so that it may read incorrectly due to the effect of element unbalance.

A partly shorted shunt coil with its reduced field tends to unbalance the electrical forces and results in incorrect indications.

Wrong connections of a three-phase power factor meter will produce readings of 60°, 120° or 180° from the correct calibration point (with load adjusted to 100% power factor). A 60° or 120° displacement of the pointer from its correct calibration point is due to incorrect phase rotation. To correct this condition, rotate the voltage connection at the line—that is *A B C* to *B C A* or *C A B* until the pointer indicates 100% in the upper or lower half of the scale. If the indication is 100% in the lower half of the scale, reverse the current leads to rotate the pointer 180° to 100% in the upper part of the scale. If the instrument indicates lag when it should indicate lead, or lead when it should show lag, reverse *any* two leads and then rotate the connections as above until indication is correct.

When the lag and lead indications of a single-phase instrument are reversed, the fault is due to the connections between the resistor-reactor and the instrument. To correct this fault, reverse the outside connections (*L* and *R*, Fig. 26) at the instrument or resistor-reactor.

(5) An open circuit in one of the voltage coils, the resistor or reactor of a single-phase instrument, or one of the series resistors of the three-phase instrument, will cause the instrument to indicate the same point regardless of power factor. To ascertain which part of the circuit is open, connect a voltmeter across each part separately and use the following reasoning. Connect a voltmeter (having a resistance approximately equal to that if the series resistor or reactor) across each coil. If the coil is open, the voltmeter will read approximately 50% of the line voltage. If the coil is not open, the voltage indication will be of a lower value. If the voltmeter fails to indicate when connected across one coil of a three-phase instrument, the resistor in series with that coil is open. With a voltmeter connected across one coil of a single-phase instrument, the resistor or reactor in that part of the circuit is open if no voltage is indicated. If the voltmeter is connected across a resistor of a three-

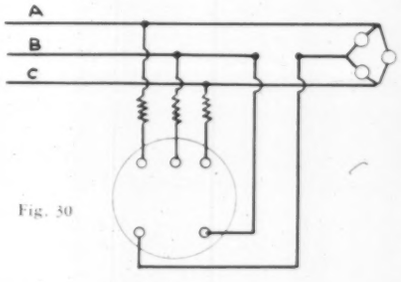

Fig. 30

phase instrument, or the resistor or reactor of a single-phase instrument, the coil in that part of the circuit is open if no voltage is indicated.

Testing or checking power factor meters in the field may consist of a complete test or just a check of a few main points. If a complete test is necessary due to making major adjustments or adding a new part, follow the outline of test as given under that heading. For periodic checks (or checks after minor adjustments) the following method should cover the operation.

In the three-phase moving-iron type power factor meter, six points may be checked without the use of a standard. If these six points as outlined below are in calibration and the element is in balance, the other points of calibration should be correct.

(1) Connect the instrument to a non-inductive resistance load as shown in Fig. 30. With this connection, the instrument should indicate 100 percent power factor in the upper part of the scale.

(2) Reverse current leads 1 and 2 and the instrument should read 100 percent power factor in the lower part of the scale.

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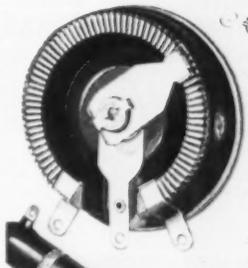

Extra quality and *extra* dependability have always been an integral part of Ohmite Resistance Units. Electrical and physical fitness for heavy-duty service in exacting applications are built-in from the very beginning. Research, engineering, testing, production and inspection all work together to make Ohmite Products always a little better.

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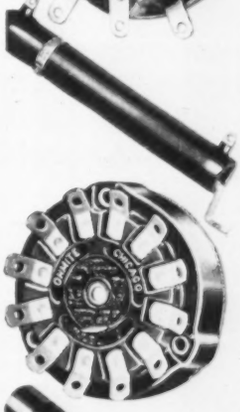

SEND FOR CATALOG AND ENGINEERING MANUAL No. 40

Write on company letterhead *for complete 96-page guide in the selection and application of Rheostats, Resistors, Tap Switches, Chokes and Attenuators.*

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(3) Next rotate the potential leads, that is, *A B C* connections to *B C A*. This arrangement should produce an indication of 50 percent power factor (lag or lead) in the upper part of the scale.

(4) Then reverse current connections 1 and 2 and the instrument should read 50 percent (lag or lead) in the lower part of the scale, 180° from reading as in step three.

(5) Again rotate potential connections, from *B C A* to *C A B*; this should result in a 50 percent lag or lead indication in the lower part of the scale.

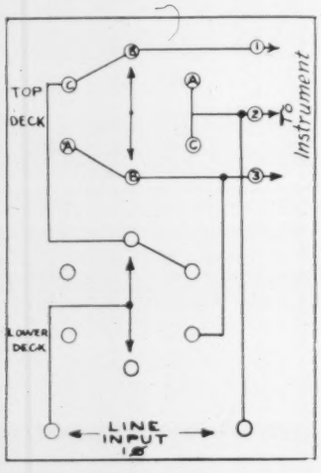

Fig. 31. Quick switching arrangement for calibrating three-phase electrodynamic type power factor meters.

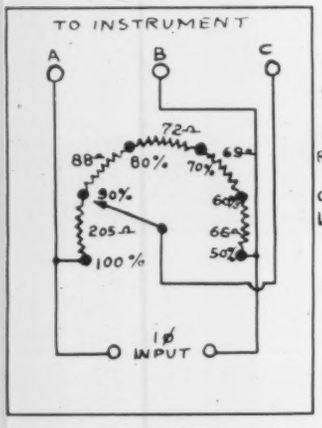

Fig. 32. Voltage dividing method of calibrating three-phase electrodynamic type power factor meters.

(6) With the potential connections as in step five, again reverse the current connections 1 and 2 and the meter should read 50 percent lag or lead in the upper part of the scale, 180° away from the indication as in step five.

A quick method of checking three-phase electrodynamic type power factor meters is as follows:

(1) Referring to Fig. 13, remove lead connected to *A* of line and connect this lead to line *C*. With this connection, both potential coils of the instrument are equally energized and the instrument will indicate 100 percent power factor.

(2) Disconnect lead *A* from line *C* and short instrument terminals *A* and *B*. With this connection, the meter should indicate 50 percent lead.

(3) Reconnect lead *A* to line *C* and disconnect lead *C* from line. Short instrument terminals *B* and *C*, and instrument should indicate 50 percent lag.

The use of a switching arrangement as shown in Fig. 31 presents a convenient means of making the above checks, or making calibration adjustments. With this arrangement, the three points (50% lead, 100%, and 50% lag) could be checked by three flips of the switch.

EDITOR'S NOTE—The arrangements shown in Fig. 31 and Fig. 32 were devised by Mr. Spencer himself; and for several years have speeded up calibrations in the department which he heads. —MFB

To check, disconnect line leads from *A*, *B* and *C* of the instrument, current leads *D* and *E* remaining connected. Connect outputs leads of switches box *A*, *B* and *C* to *A*, *B* and *C* of the instrument, and input of switchbox to line leads *A B* or *B C*. With these connections, the switching arrangement as shown in Fig. 31 will result in power factor indications on the instrument of 50% lag, 100% and 50% lead.

If it is desired to check points between 50% and 100% power factor, a voltage dividing method as shown in Fig. 32 may be used. This arrangement consists of five resistors connected as shown in Fig. 32 to give the desired ratios of divided voltages for power factor readings of 50, 60, 70, 80, 90 and 100 percent power factor, lag or lead.

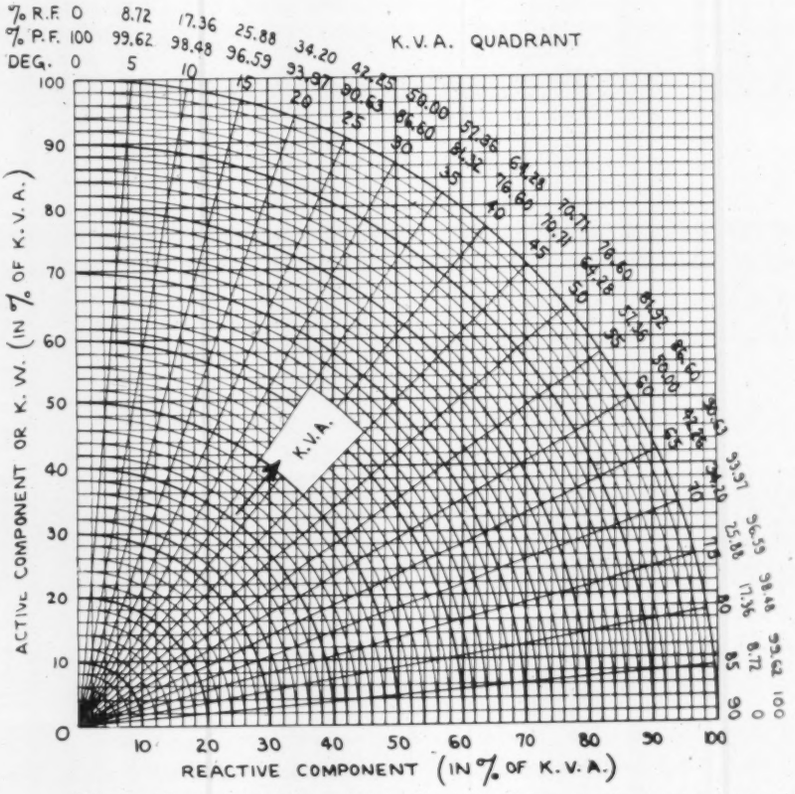
% R.F. 0 8.72 17.36 25.88 34.20
% P.F. 100 99.62 98.48 96.59 93.97
DEG. 0 5 10 15 20
K.V.A. QUADRANT
ACTIVE COMPONENT OR K.W. (IN % OF K.V.A.)
REACTIVE COMPONENT (IN % OF K.V.A.)
K.V.A.
0 10 20 30 40 50 60 70 80 90 100

Fig. 33. Chart showing inter-relations of reactive factor, reactive component, power factor, active component and kva. for any angle of lag or lead.

Either of the above outfits could be made at low cost and would be small enough for a service man to carry in his pocket.

Single-phase power factor meters may be checked with a standard power factor meter of known accuracy or with an ammeter, voltmeter and wattmeter. The 100 percent point may be checked by connecting the instruments to a circuit having a non-inductive load and reading all the instruments simultaneously. If the power factor meter reads 100 percent, when the volt-amperes (volts × amperes) equals the watts, the power factor meter is correct at that point. Other points on the scale may be checked by varying the power factor, using a phase shifter, or by introducing inductance or capacitance in the circuit. With each change of phase relation between current and voltabe, read the instruments and apply the formula watts times 100 divided by volt amperes equals percent power factor.

REACTIVE FACTOR METERS

...ctive factor is the factor by which the total volt-...es of a circuit is multiplied to give the reactive volt-...es. It may also be expressed in percent and is the ...f the angle of lag or lead of the load current of a ...t to the voltage. As power factor is the ratio of power ...lt-amperes, so reactive factor is the ratio of reactive ...mperes to the total volt-amperes. Reactive volt-...es of a circuit is found by taking the square root of ... difference between the square of the apparent power ... the square of the true power. Also other formulas, ...mple:

Given 10 volt-amperes as read with ammeter and voltmeter and 8 watts as read with wattmeter

then P.F. = 8/10 or 80%

R.V.A. = $\sqrt{10^2-8^2} = \sqrt{36} = 6$.

then R.F. = 6/10 or 60%

or $\sqrt{[1-(W/VA)^2]} = \sqrt{[1-(8/10)^2]} = \sqrt{.36} = .6 = 60\%$

With sine wave current and voltage the reactive component of current is in quadrature with the voltage.

The chart, Fig. 33, should be helpful in refreshing the reader's mind as to the relationship existing between the reactive factor, reactive component, power factor, active component (kw) and kva. for any angle of lag or lead of the current.

Construction:

The construction of either the moving-iron or the electrodynamic type of reactive factor meter is the same as that of the corresponding type of power factor meter. With the exception of their respective dials, a power factor meter and a reactive factor meter are alike; and the calibration identifies each for its application.

Principle of Operation.

Same as power factor meter for both electrodynamic and moving-iron types.

Applications.

Certain types of synchronous machines, such as synchronous converters, are designed to operate at unity power factor; in other words, with a minimum idle volt-amperes. Any divergence from this condition greatly increases the heating of the windings. As this heating is a function of the reactive factor of the volt-amperes, an ordinary power factor meter indicates this condition somewhat indirectly. Thus, with a power factor indication of 95%, which the average operator considers good, there are 31.5% reactive volt-amperes flowing. A direct indication of reactive factor is thus preferable on all synchronous machines designed primarily for operation at high power factor. Overheating of the armature will result if the pointer is not held at zero (from instrument card I.C. 5010). Like the power factor meters, the reactive factor meters are made in single-phase and three-phase types, the single-phase meters being applicable to single-phase, two-phase and three-phase (line to neutral) circuits. Single-phase meters are calibrated special if required to check three-phase circuits without a neutral.

Test and Inspection.

The calibration adjustments and the inspection of the reactive factor meter are similar to that of the power factor meter. The open distinctly-marked scales are calibrated to indicate the sine of the angle of lag or lead of the load current to the voltage of the circuit. A power factor meter standard may be used to calibrate the points on the scale.

Connections.

Both the internal and external connections of the reactive factor meter are the same as those of the power factor meter.

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Recorder-Controller

Boiler Meters for recording combustion conditions and guiding boiler operators. Described in Bulletin No. 44.

Multi-Pointer Gages for indicating factors such as draft, pressure, temperature and speed. These Gages are available with any number of pointers and any scale combination; in either the oil sealed bell or diaphragm construction.

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Flow Meters for indicating, recording and integrating the flow of steam, water, sewage, air, gas and other fluids. Bulletins No. 39 and 300.

Recorders for pressure, temperature, drafts, liquid level and other factors.

G-3

BAILEY METER COMPANY

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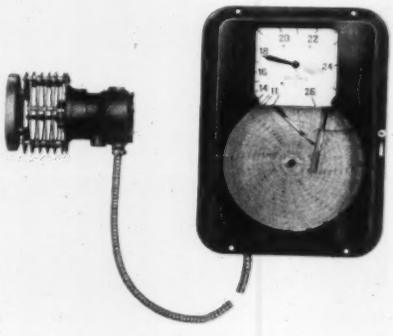
The Month's NEW INSTRUMENTS

In this department we strive to report each month ALL the new devices for measurement, inspection, testing, metering and automatic control—in the form of concise technical descriptions. When writing to manufacturers directly, please mention this department as your source of information. Or write to Information Section, Instruments Publishing Company.

Radiation Pyrometer

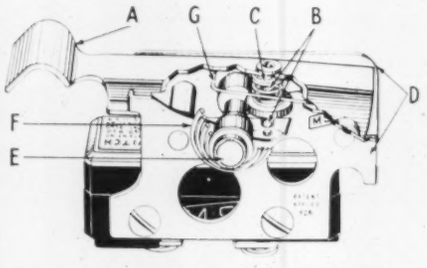
New radiation pyrometer, known as the "Pyrovac," is designed for recording, indicating, or automatically controlling temperatures in furnaces and kilns above 900°F., i.e., temperatures that fall into the following classifications: (1) High temperatures



beyond thermocouple range; (2) Temperatures for which rare-metal thermocouples are used; (3) Surface temperatures, such as roof, wall, duct, lining, or retort temperatures and the temperature of the work itself rather than furnace or kiln temperature surrounding the work. (4) Where object is moving, is inaccessible, or where there are space limitations. The Pyrovac Radiation Pyrometer's temperature-sensitive unit or radiation head is mounted on the outside of the furnace out of the hot zone.—*The Bristol Co., Waterbury, Conn.*

Micro Switch Actuator with Mechanical Reset Action

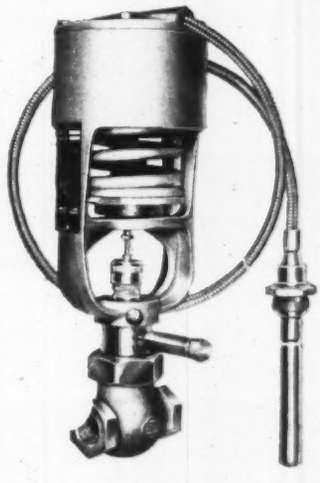
Designed for use in the throttle mechanism of aircraft, new Type "T" Switch Actuator provides a light-weight, compact mechanism for performing a widely useful



three-step operation, steps in cycle being: (1) closing a circuit by depression of an actuating arm; (2) opening circuit by mechanical release of the normally-open Micro Switch while actuating arm is held in depressed position; (3) return of actuating arm to normal position. Parts of Actuator shown in drawing, are: *A*, actuating arm; *B*, switch-operating plunger; *C*, plunger washer and spring; *D*, side plates forming frame of the Actuator (these are rigidly joined by two riveted steel pillars); *E*, release rod; *F*, release rod conical spring; *G*, actuating arm spring. As used in aircraft, Actuator employs "Micro Switch Type R31" switch. Army Air Corps approved and replaceable in the field. Manufacturer advises that Actuator is considered part of the aircraft, and no deviation permit is required. The "T" Actuator is supplied as a single unit, or in gang assemblies of 2, 3, or 4 units, left- or right-hand, spaced to meet customer's requirements. Other variations such as pull- instead of push-button release, can be supplied, and the Actuator may be used with basic Micro Switch units other than "Type R31." — *Micro Switch Corp., Freeport, Illinois.*

Self-operating Controllers

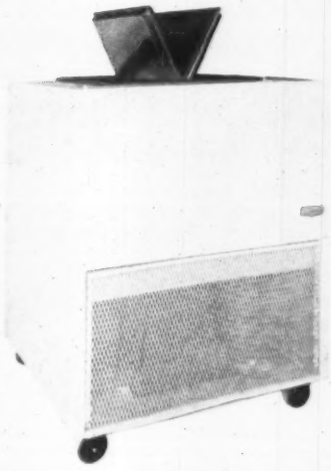
A new line of "TAG" temperature controllers — entirely self-contained and self-operating — is announced, for applications such as hot-water storage heaters and storage tanks, canning retorts, exhaust boxes,



textile dryers, scouring bowls, etc. Controller uses no power outside of the energy developed in its own system. Temperature changes at the bulb raise or lower the vapor pressure of the volatile liquid in the tube system, causing the power bellows to expand and contract and position the steam valve.—*C. J. Tagliabue Mfg. Co., Park & Nostrand Aves., Brooklyn, N. Y.*

ndustrial Cold Chambers

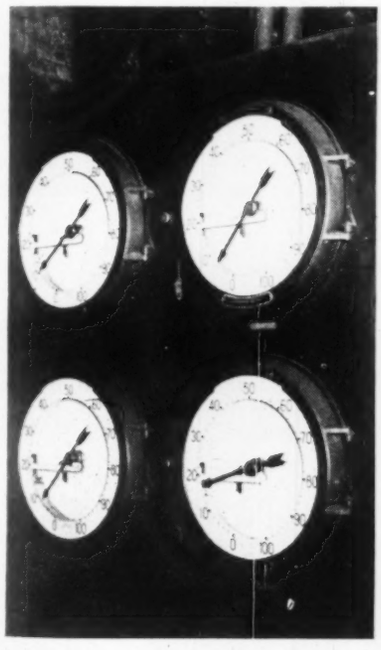
s models of maker's "Industrial Sub-Machines" are announced, so that a of capacities is now offered ranging to 11 cu. ft., with top or side open-



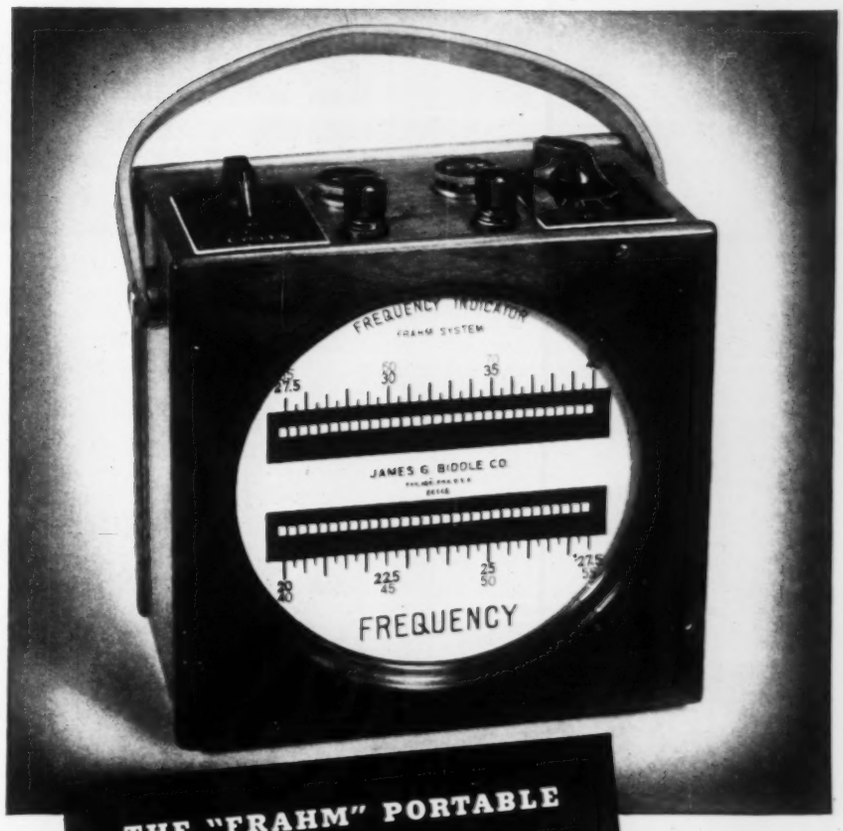
ings, and in a choice of four temperature ranges (−45, −60, −75 and −90°F. low limits). Illustration shows a new top-opening model of 4 cu. ft. capacity, with 6" insulation and temperature control to ±3°F. (closer control available on special order). —*Kold-Hold Mfg. Co., 124 N. Grand Ave., Lansing, Mich.*

Smoke Density Indicators and Recorders

Boiler operators in industrial and public utility power plants can follow smoke abatement schedules more easily, often with improvement in boiler efficiency, by means



of new "Micromax" smoke density indicating and recording equipment. A continuously-flowing sample of smoke is drawn from stack, breeching or duct, is measured by a standard "Micromax" potentiometer recorder, and the result is continuously indicated and recorded in terms of smoke density.—*Leeds & Northrup Co., 4934 Stenton Avenue, Philadelphia, Pa.*



THE "FRAHM" PORTABLE
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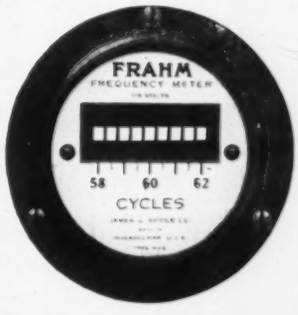
FREQUENCY METER

As dependable as it is rugged, this wide-range Portable Frequency Meter is a vital adjunct to any laboratory or testing department. The set of synchronously vibrating (or *tuned*) and electro-magnetically actuated reeds do not easily get out of order or lose calibration; and they are unaffected by wave form or by ordinary temperature changes. Various ranges to as low as 10 and to as high as 500 cycles per second are available in both portable and switchboard types.



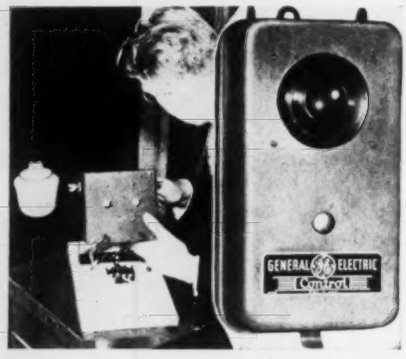
The Miniature type Frahm Frequency Meter has recently become popular, largely because it has the same ruggedness and dependability of the larger instruments.

Write for descriptive Bulletin 1695-I.

James G. Biddle Co.
1211-13 ARCH STREET *Electrical and Scientific Instruments* PHILADELPHIA, PA.

"Blackout Sentinel" and "Light Watchman"

(1) Newly-designed photoelectric "Blackout Sentinel," which automatically turns off advertising or store window lights when street lights go out, was recently given its first practical demonstration in Binghamton, N. Y., during Binghamton's third trial blackout. Equipment, installed in a second-floor window of a Binghamton bank (see left-hand illustration) consisted of a small box containing a phototube and relays. This was directed on a street light outside the

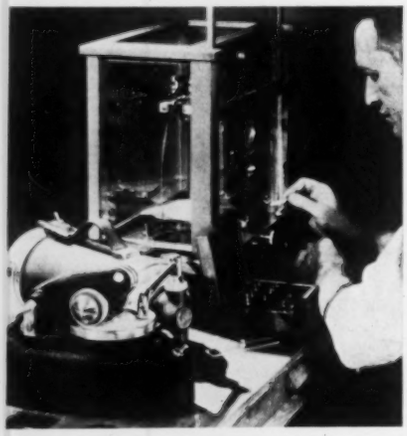


bank; when street lights went out during the blackout a large neon advertising sign on the roof of the bank was automatically extinguished. At the end of the 15-minute test the street lights came on and the sign was automatically relighted.

(2) New "Light Watchman" serves similar purpose. This relay has several features which make it especially suitable for blackout lighting control. It is highly directional, to make it subject only to the control of the street light at which it is aimed. Moreover, a short time delay prevents false operation of the relay by momentary flickering of street lights. Relay is so designed that if either of the two tubes fails or if the sensitive relay coil is open-circuited, the relay is de-energized and the lights are turned off. The operation of this device will not affect the normal functioning of a time switch, if one is used to turn on the lights at dusk and turn them off at a preselected time. "Light Watchman" is available in indoor or outdoor types, this latter being shown in the right-hand illustration.—*General Electric Co., Schenectady, N. Y.*

Vacuum Pickup for Abrasion Tester

New "Model HV-42 Abraser Vacuum Pickup" is an accessory to the "Abraser" (see *Instruments*, Sept. 1937, page 227; July 1939, page 172; May 1940, page 122; March 1941, page 64). Primary function of Vacuum Pickup is to prevent accumulation of abradings from interfering with normal wear action of the "Calibrase" wheels. Its principal application is removal of abradings that may become embedded in the weave of textile fabrics. Also fine powder from certain types of organic coatings that tend to cling to and build up on face of wheels. Pickup is of tubular design for standing on the table beside Abraser; has a nozzle rotatably mounted on suction end of housing so as to swing in and out of position relative to specimen holder. Nozzle holder can also be adjusted vertically to proper height above specimen by turning knurled collar located on stem. Contaminated air is drawn through a filter bag which passes only clean air back into the room. Bag can be quickly removed for emptying. Motor is high-speed universal type designed for operation on any electrical circuit of 110 to 120 volts. Toggle switch is conveniently located at one end of the lifting handle.—*Taber Instrument Corp., North Tonawanda, N. Y.*



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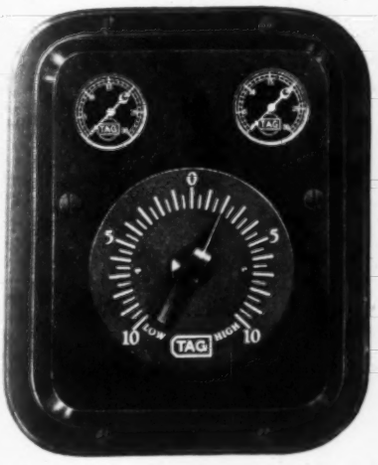
Microfilm Reader

New Spencer Microfilm Reader is said to be the first inexpensive instrument designed to reproduce the almost microscopic characters of microfilm with brilliant fidelity.

It consists of projection head, glass film book, and shadow box and screen. Projection head incorporates an inexpensive spotlight type of longlife bulb, condensing system and specially designed projection lens. Head is held by spring clips to the shadow box, which also serves as a support, and may be rotated to project the film in either a vertical or horizontal meridian. *Operation:* Microfilm is placed in glass film book and moved to show the desired page or illustration by easy manipulation. Glass film book consists of two pieces of glass, hinged and bound at the edges with transparent Cellophane tape. Tape serves to space the film properly, to protect it from scratching and to orient the film in relation to focal plane of objective. Image is projected onto special screen and is so protected by shadow box that a darkened room is unnecessary. Image is flat and undistorted and microfilm material may be read for hours without optical fatigue or discomfort. An iris diaphragm in objective permits adjusting light to user's comfort. Screen is of special tinted paper which has been found to render a projected image of agreeable color and contrast; is easily replaceable when soiled or damaged. Extra screens are available in packages of six. Instrument will accommodate rolls of film from a few inches to several feet in length. When long rolls are used, it is desirable to use roll film attachment designed to accommodate rolls of film up to 100′ in length.—*Spencer Lens Co., Buffalo, N. Y.*

Non-indicating Controller

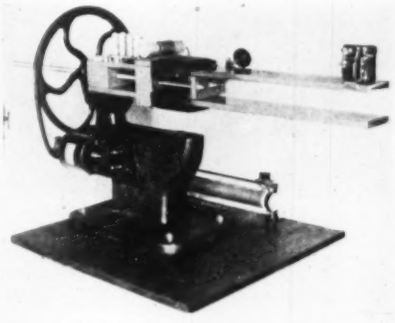
Simplified new controller, to be known as "TAG Number 42," is said to be ideally suited to the majority of automatic control applications. Basically, the movement utilizes TAG Principle of Control." It has been



redesigned for compactness so that the few simple parts are accessible. Small size (5¾" × 7¼") does not affect easy interchangeability of tube systems. Temperature changes at the bulb actuate TAG Ball Air Valve through novel transmitting spring lever that multiplies movement of powerful capsular spring. Air valve, in turn, governs rate of flow through the diaphragm-operated control valve in the steam line. It is said that the sensitiveness is high, that the accuracy is permanent and that the durability of the assembly has been proved by 24 years of service records. Temperature and pressure models of this controller are available in a number of convenient ranges. —*C. J. Tagliabue Mfg. Co., Park & Nostrand Aves., Brooklyn, N. Y.*

Vibrating Table

New tuning-fork type Vibration Tester is specifically designed to eliminate transmitting vibrations to the building, while giving accelerations as high as 30*G* to the object under test. Vibrator generates frequencies of 20 to 60 cycles per second, is adjustable for both frequency and ampli-



tude. Frequency is adjusted by extending or decreasing length of tuning-fork arms, by means of a reversible motor. Amplitude is adjusted by varying the power supplied to the instrument. A reed tachometer indicates frequency and a special indicator shows amplitude of vibration at all times from zero to ½", both in 1/64" or ½ mm. divisions. When the vibrating arms are properly counterbalanced, they will impart an accelerating force of 150 lbs. to a 5-lb. weight. The vibration imparted to the table is so slight that a light object placed on it will not be disturbed.—*Kurman Electric Co., Inc., 241 Lafayette St., New York City.*

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AIR CORPS, NAVY, MAJOR AIR LINES, UTILITIES, INSTRUMENT MANUFACTURERS AND USERS, PRODUCERS OF JEWELS AND BEARINGS, MUNICIPALITIES, AND INDUSTRIES REQUIRING AN EXTRAORDINARY, INEXPENSIVE CLEANING PROCESS.
To operate: Parts placed in work basket (A) (volume capacity 5½" ID x 3⅝" deep) are agitated in first jar (B) containing L & R POWER NOFOME CLEANER, in second jar containing L & R RINSING SOLUTION, in third jar containing L & R RINSING SOLUTION and then are dried in self contained heater chamber (C). Parts are cleaned and dried thoroughly of grease, grime and discoloration in continuous operation, without causing rust, corrosion or removal of metal. Perfect, uniform results, amazing savings in man hours. Almost 15,000 L & R Machines already in use.
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Standard Equipment USES
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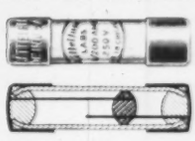
"Quicker than a Short Circuit"



Littelfuse Locked Cap Assembly (U. S. Pat. No. 1922642). Positively locks cap to tube. Hermetically seals filament. Protects fuse, and prevents loss of cap with markings.

FOR UTMOST PROTECTION—MONEY-SAVING ECONOMY

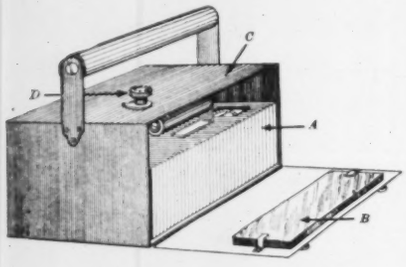
Cap Assembly only one of several LITTELFUSE FACTORS — not "equivalents." Littelfuse construction means *added* mechanical strength—*added* resistance to fatigue—*added* vibration life.

INSTRUMENT FUSES for meters 1/200 amp. up. Hi-volt ranges, 1/16 amp. up. All types Littelfuse for aircraft, radio, auto, etc., and mountings. Send for complete catalog.

LITTELFUSE INC. 4759 RAVENSWOOD AVE. CHICAGO, ILL.

Glossmeter

New 60° Glossmeter has been designed to test samples for compliance with specifications for original gloss and to measure gloss of surfaces. The 60° angle and other features conform to ASTM Specification D523-39T. Available in battery and transformer models. Illustration shows the *battery-operated* set. (A) Glossmeter in carrying compartment; (B) black glass gloss standard; (C) carrying case containing batteries; (D) rheostat. Battery box supplied



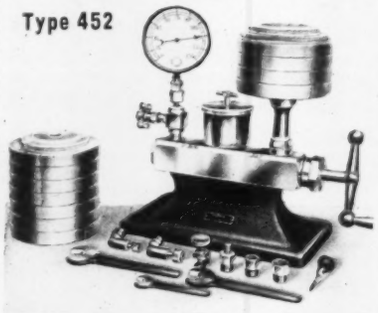
with battery type Glossmeter holds nine 1½-volt dry cells. Instead of dry cells, two 6-volt automobile batteries in series may be used. Continuous operation of the lamp, instead of the intermittent operation necessary with dry cells, is possible when the 6-volt batteries are used. This portable instrument is well suited for field and test fence work. Changes in gloss may be followed without removing specimens from positions in which they are being exposed. *Glossmeter With Transformer* for use on 110 or 220 volt circuit is longer than battery type, but otherwise identical. Black glass for calibration is attached to side of instrument. *Operation* (either type): Place instrument on surface to be read, holding handle in right hand, and depress the switch with the thumb. The gloss may be read on the scale immediately.—*Henry A. Gardner Lab., 1506 Rhode Island Ave., Washington, D. C.*

Multiple-supply Automatic Oxygen Regulator

New "07-A-11" Automatic Oxygen Regulator was designed to meet demand for an instrument that is "infallible, absolutely dependable, light in weight, easily adjusted, simple in operation, and that requires a minimum of effort and attention by the plane personnel." It is excellently adapted to use with the continuous flow type of mask; exceptionally well suited for use at altitudes above 25,000 feet. Regulator is designed to regulate supply of oxygen to a manifold line accommodating up to ten persons. It automatically controls pressure in manifold according to altitude, maintaining predetermined absolute pressure against a metering orifice installed at each delivery station into which the mask may simply be plugged in. (An improved Flowmeter is also available for installation at this point if desired.) The oxygen is supplied from cylinders varying in pressure from 1800 lbs./in.² when full, to 50 lbs./in.². Regulator resembles the Army Air Corps Type A-11, Specification 2X-40334, in performance. Regulator comprises a one-piece duralumin body incorporating inlet and outlet connections, two stages of pressure reduction, two relief valves and a duplex gage. First stage of pressure reduction reduces supply pressure to about 30 lbs./in.² differential pressure between chamber and atmospheric pressure. This stage is provided with a relief valve adjusted to open at about 50 lbs./in.² pressure. The oxygen at this reduced pressure supplies the second stage which comprises an aneroid, contained in the chamber, which controls the inlet valve to this second stage of pressure reduction. supporting member of this aneroid is vided with a flexible seal of small dia mounted on a flexible metallic diaph forming a wall of the chamber, in ord allow transmission of motion from an nal aneroid to the internal one, and t troduce a differential pressure effect the regulation of the absolute pressu the second stage. (This is necessary to duce the required manifold pressure altitude relationship.) A wall with a c flexible seal separates the internal an from the valve which it actuates, thus f ing an aneroid compartment and an ox flow compartment. This chamber is vided also with a relief valve which is justed to open at a pressure of about lbs./in.². Valves in both stages of pressure reduction are identical in design; are so arranged that inlet pressure is in the direction of closing them. Valves comprise a molded neoprene seat acting against a metal port. Design is such that excessive compression of the neoprene is prevented in the closed position by metal-to-metal contact after the neoprene is compressed to a sufficient predetermined amount. Dial markings and pointers of the duplex gage conform with Fig. 1 of Air Corps Spec. 2A0319 of Type A-9. Flow indicator is responsive to the differential pressure between supply manifold and atmospheric pressure and is calibrated in thousands of feet altitude. Lower gage indicates the cylinder pressure. Inlet and outlet connections receive Air Corps parts 811BT5D and 811T5C'S. An important feature of this instrument is elimination of gaskets throughout, which contributes to permanence of adjustments and freedom from set. This, together with small number of moving parts and low friction, accounts for uniformity of flow and freedom from hysteresis.—*Gaertner Scientific Co., 1201 Wrightwood Ave., Chicago, Ill.*

AMTHOR Dead Weight Pressure Gauge TESTER

Type 452



Modern design and construction puts this rugged precision instrument in a grade above the ordinary dead-weight testers.

Made in eight ranges, to 3000 lbs. maximum.

We guarantee 1/10 of 1 percent accuracy in each range.

The Type 452 is designed for simplicity and compactness. It incorporates the newest refinements and improvements. Adapters and tools are supplied, as well as either carrying case or protecting cover.

Immediate and intelligent attention will be given to your inquiries on all industrial speed measurement problems. Drop us a line today.

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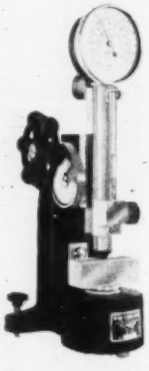

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The Shore Instrument & Mfg. Co., Inc.
9025 Van Wyck Ave., Jamaica, N. Y.

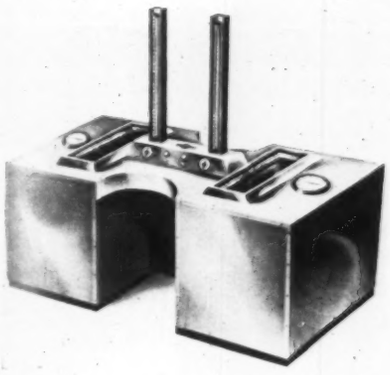
Photoelectric Intrusion Protection System

New "Type A28L Control" is a long-range photoelectric burglar alarm control for protection against intruders and saboteurs. The light source projects a practically invisible

light beam for distances of 350 to 700 feet and it is possible to completely surround power plants, factories and other areas. If the light beam is broken by intruders, or saboteurs, the photoelectric relay contacts close, thereby sounding alarms, operating a central station system, turning on floodlights, closing gates, etc. Control is provided with a latching unit including a push button station which may be located in the gate house, office, or other convenient point. This serves to latch the alarm in operation once the light beam has been momentarily broken until the reset button is operated. Equipment is unaffected by changes in local light and is designed to operate 24 hours a day. The relay contacts are pure silver and will handle 15 amps. a.c. and 8 amps. d.c. Control operates from 115 volts a.c. source of supply.—*Photoswitch Inc., 21 Chestnut St., Cambridge, Mass.*

Constant-temperature Baths

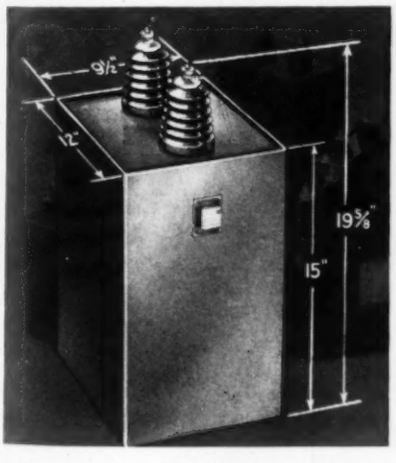
dual installation of constant-tem- oil baths speeds and simplifies ion testing and calibrating of instru- ells and other parts or components. constant temperatures are variable



in a wide range by pre-selection thereby making the installation adaptable to tests of different parts without decommissioning periods. The two-bay arrangement allows two operators to perform tests. Note also the location of the indicators convenient for operators and inspectors. The entire unit is automatic and requires only electrical connection to plant lines. The baths can be provided in any dimensions required. —*Mobile Refrigeration, Inc., 630 Fifth Ave., New York City.*

High-voltage Heavy-duty Oil Capacitors

Requirements of applications calling for high-voltage heavy-duty oil capacitors are met by new "Type '20" oil capacitors covering voltage ratings from 6000 to 50,000



D.C.W., including dual-section units for voltage-doubling circuits of 12500-12,500 volts or 25,000 volts output, in 0.25-0.25 and 0.5-0.5 mfd. Multi-laminated kraft tissue and aluminum foil sections are uniformly and accurately wound under critically controlled tension to avoid mechanical strains. Sections are thoroughly dried, vacuum-treated, oil-impregnated and oil-filled under continuous vacuum. It is claimed that by reason of the Hyvol dielectric oil used, these capacitators maintain their full-rated capacity even at freezing temperatures. Hermetically sealed in welded steel containers with cork-gasketed pressure-sealed glazed porcelain high-tension pillar terminals, these capacitors are immune to humidity, temperature and climatic conditions generally.—*Aerovox Corp., New Bedford, Mass.*

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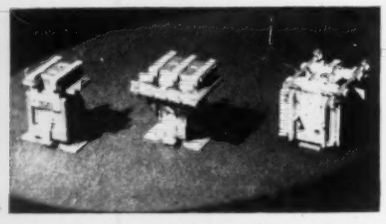
Relays for Aircraft Service

Three new relays designed especially for aircraft applications where lightweight, suitability for severe vibration conditions, and operation at high altitudes at rated current are of first importance, are also applicable to tank installations:—

(A) Single-pole relay is available in two forms—single-circuit with one normally-open contact (CR2791-B100A), and two-circuit with one normally-open and one normally-closed contact (CR2791-B100C). It has a maximum continuous current rating of 20 amperes at 12 or 24 volts, and a maximum



(A) (B) (C)

make or break rating of 100 amperes at 12 or 24 volts. Coil operates at 1.2 watts. Relay weighs 3 ounces in the normally-open form, and 3.4 ounces in the n-o.&n-c. form. Tip travel is 1/32" and tip pressure is 40 grams. Relay is $1\frac{3}{4}$" wide, $1\frac{5}{8}$" deep, and $1\frac{5}{8}$" high.

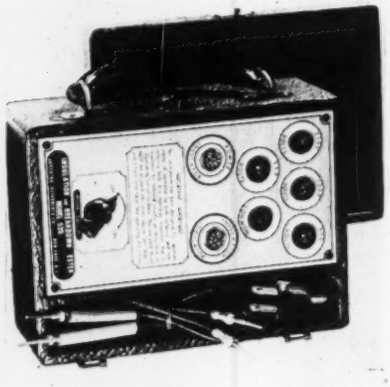
(B) High-voltage relay (CR2791-D100F) is special for use with aircraft radio transmitting equipment. Ceramic insulation and double-break contacts permit control of 1,000 volts d.c. Contacts have maximum current ratings of 0.02 ampere at 1,000 volts d.c. and 0.1 ampere at 500 volts d.c. Coil wattage, 1.2; tip travel, 1/16" double-break; tip pressure, 25 grams. Contacts are arranged for d-p.d-t. double-break operation. Relay is 2 5/16" wide, 1 1/16" deep, 1 1/16" high.

(C) Two- and three-pole relays are provided in two forms. One (CR2791-B100D, G) has one normally-open circuit per pole; the other (CR2791-B100F,J) has one normally-open and one normally-closed circuit per pole. These relays have maximum continuous current ratings of 8 amperes at 12 or 24 volts, and maximum make or break ratings of 25 amperes at 12 or 24 volts. Coils operate at 1.2 watts. Both two-pole forms are 1 25/32" wide, $1\frac{3}{8}$" deep, 1 21/32" high, and weigh 3.5 ounces. The three-pole forms are 1 25/32" wide, $1\frac{7}{8}$" deep, 1 21/32" high, and weigh 3.75 ounces. All four forms have a tip travel of 1/32" and a tip pressure of 28 grams.

All three of these relays are designed for use in a wide range of ambient temperature, from −40°C. to 95°C. They are suitable for use at rated current at altitudes from sea level to 40,000 feet, and are corrosion-proof, meeting Navy 200-hour salt-spray tests. They are good for mechanical frequencies of 5 to 55 cycles per second at $1/32$" maximum amplitude (1/16" total travel) applied in any direction. Contacts remain in correct position when relays are subjected to a linear acceleration of 10 *G* in any direction.—*General Electric Co., Schenectady, N. Y.*

Insulation and Breakdown Tester

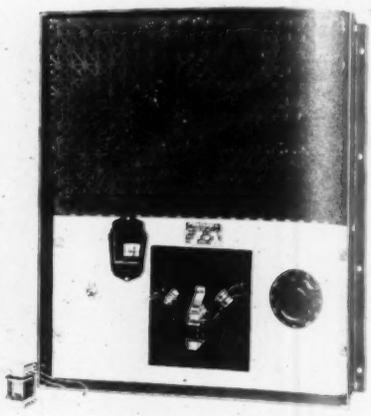
New "Model 520" Insulation and Breakdown Tester features a super-sensitive danger indicator which lights up to indicate leakage up to 1,000 megohms. Four voltage



sources are available 250, 500, 1,000 and 2,500 volts. No hand-cranking and no adjustments are necessary. To use, connect the two test leads to the circuit, appliance or motor to be tested, then throw the switch. The danger indicator will light up to indicate defective insulation, or insulation which, because of its excessive leakage, indicates a potential or imminent breakdown. Tester will also indicate shorts and opens. Pilot lamp on front panel indicates when high voltage is on. Instrument is housed in a portable carrying case with compartment for test leads; operates on any 90 to 125 volt 60-cycle a-c. Size 6" × 8" × $4\frac{3}{4}$".—*Superior Instruments Co., 227 Fulton St., New York City.*

Coil Testing Equipment

Announcement is made of a [illegible] series of coil testing machines, each unit capable of quickly checking all of the electrical properties of a coil in one handling. Tests



are provided for checking the limits of insulation resistance, coil resistance, effective a-c. resistance, inductance, and shorted turns. Additional tests are for checking effective turns, direction of windings, and other properties. There are two types of units—automatic and semi-automatic. Each unit has a holder adapted to the special shapes of coils to be tested. Illustration shows a semi-automatic unit capable of making eleven tests in quick succession on each coil, and checking up to 250 coils per hour. Operator attaches coil to holder at center of panel, pushes terminal wires into spring clips and turns large knob one step at a time. Design is such that, at each step, pointer of illuminated galvanometer must cross center of its dial by moving from left to right, or from right to left. Operator watches for this movement and, if it occurs, knows that the coil has passed that test. If pointer does not cross center of dial for some one test, then "the nature of the defect in that coil is read directly from the lettering on the knob." Unit illustrated is designed to check a special coil with three windings: holder at center of panel is designed to fit this particular coil shape. Unit checks resistance of each winding by the "high-low bridge" method; checks the effective a-c. resistance at 900 cycles; checks the direction of each winding; and finally checks the high and low

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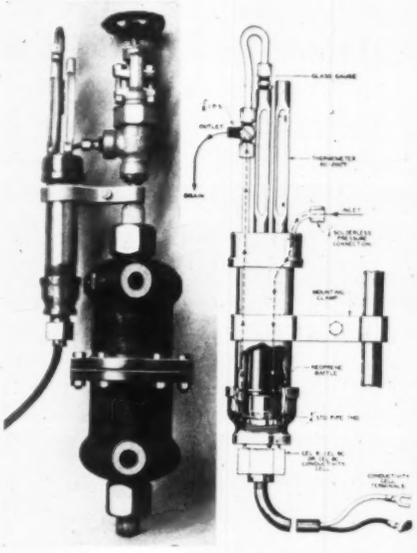
of inductance. All of these tests performed in a few seconds. An automachine for the same purpose uses to supervise itself and to pass from st to the next without attention from erator. "Up to 300 complicated coils oir" may be tested automatically for ssible defects. Operator merely inand removes coils, and notes presence defect from a bank of lamps.— *Bell Corp., 116 Nassau St., New York*

Condensate Sampler for Conductivimetric Checkup

Routine checkup of boiler water concentration or steam condensate by electrical-conductivity means is said to be reduced to simplest terms by means of new Condensate Sampler. This device provides a means of sampling condensate for a conductivity cell which in turn connects electrically with a suitable measuring or checking instrument calibrated in direct-reading terms such as percentage of carry-over or soluble salts. Or, by means of a suitable device, a warning signal is automatically actuated when condensate exceeds set limits, or a corrective means is automatically set in motion. Maker's "Solu-Bridge"



(see *Instruments*, Oct. 1939, page 274; April 1940, page 91) and "Solu-bridge Controller" (see *Instruments*, Sept. 1939, page 244; March 1940, page 64; April 1941, page 88; July 1941, page 204) can be used for these functions. Conductivity cell holder is available alone for use with any type of condensate cooler, or in combination with a new type of condensate cooler recently available. Cell holder admits condensate or cooled boiler water through its ¼" solderless pressure-connected copper pipe. An outlet with a two-way control cock releases the condensate to the drain pipe. A Neoprene baffle within sampler chamber insures proper circulation of condensate past conductivity cell screwed in at bottom of chamber. A thermometer indicates temperature of condensate (a vital factor in conductivimetry). A sight gage shows up presence of any oil in the condensate: if present, two-way drain cock is turned to the oil-drainage position. For simplest installation, combination condensate cooler and cell holder assembly is available, comprising cell holder already described, plus a condenser, the two units being mounted together. "This complete condenser-sampler combination is virtually a packaged job." (User does not have to bother with gathering various items, nor with piping, cutting, threading, etc.) — *Industrial Instruments, Inc., 156 Culver Ave., Jersey City, N. J.*

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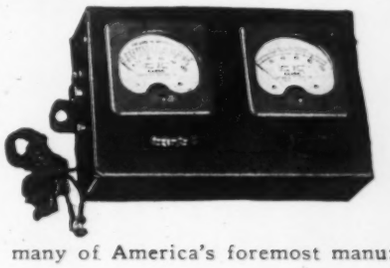

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(PIRANI TYPE)

Shown at left is meter box of our model No. 6 gauge.

This gauge successfully used by many of America's foremost manufacturers.

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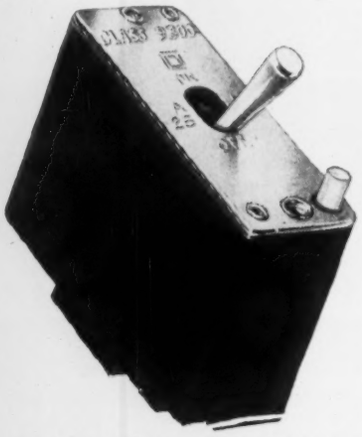
Weld Cooling Time-temperature Controller

Newly developed and patented principle featured in new "Series 4400" time-temperature program controller, makes simple the compliance with government specifica-

tions for controlled cooling rate of welds. (1) Interwires between thermocouple and any type of pyrometer-controller. (2) Only two knob settings: (A) desired rate of cool, (B) time that rate is to be maintained. (3) For use with any type of automatic temperature control system. (4) Sheet steel surface-mounted case, 14" × 14" × 5" is dust-tight; can be supplied with flange for flush mounting. (5) Interrupter included which provides for periodic readings or recordings throughout entire program without disrupting accuracy of cool rate. (6) Indicator lights show progress of program. Complete line available in any number of standard and special types for controlling all phases of heating, soaking, and cooling periods for any time-temperature program. —*Automatic Temperature Control Co., Inc., Philadelphia, Pa.*

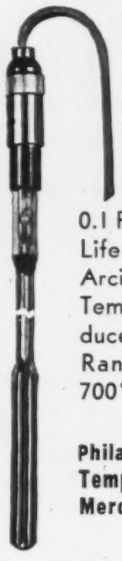
Aircraft Circuit Breaker with Trip Indication

New "Class 9300 Type A" circuit breaker with trip indication is a further development of maker's standard aircraft circuit breaker. In the same size enclosure, parts are added so that when the breaker trips



due to over-current, a red button appears on the breaker faceplate as shown. This signal is in addition to the toggle lever moving to the "off" position. The red button tells the pilot that he has lost that circuit due to over-current. On resetting, the red signal disappears. In manual operation of the breaker to "on" or "off", the red signal does not appear. It only shows when the breaker has tripped due to over-current.—*Regulator Div., Square D Co., 6060 Rivard St., Detroit, Mich.*

Philadelphia Merc-to-Merc Thermo-Regulators Feature



Mercury to Mercury Contacts : Increased Contact Capacity : Sensitivity within 0.1 F. Exceptionally Long Life and Stability : No Arcing : No Oxidation : Temperature Lag Reduced : Temperature Ranges adjustable to 700°F.

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Philadelphia Merc-to-Merc Temperature Controls and Mercury Plunger Relays

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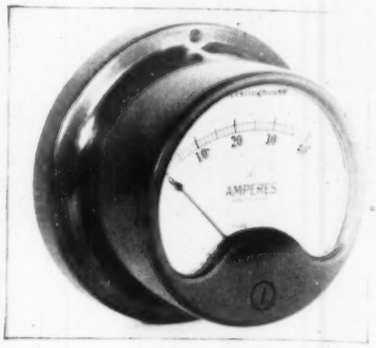
Miniature Instruments

For control panels, industrial test [illegible] radio transmitters and general test [illegible] in electrical laboratories, a new [illegible] of miniature panel instruments is availa[illegible] in d-c., a-c., thermocouple, and rectifier [illegible], all in the 3½" class, for indicating [illegible] and amperes. They are made w[illegible] a



chassis construction permitting only a change in cover to make up square, circular, flush or projection type instruments. Capacities as low as 20 microamperes are available for d-c. measurement. Self-contained ammeters to 100 amperes and voltmeters up to 500 volts (both a-c. and d-c.) are available. Higher ratings may be obtained by using resistors, shunts, or transformers. Rectifier instrument dials are calibrated in r.m.s. values with a sensitivity of 1000 to 5000 ohms per volt. These are used for measuring a-c. values when low energy consumption is important. Thermocouple styles are available with either self-contained or external thermocouples developed for maximum overload and stability and are used for measuring r-f. currents. Frequency errors have been minimized and overall design is balanced to give minimum capacitive or inductive errors. Features common to all instruments in this classification are permanent white dials, high torque-to-weight ratio, and Moldarta cases.—*Westinghouse Electric & Mfg. Co., Plane & Orange Sts., Newark, N. J.*

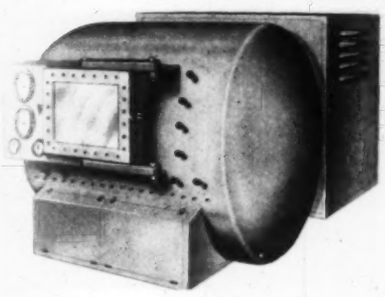
Folding Pocket Stereoscope

New "Model CF-8," especially designed for use with vertical aerial photographs, is said to be a great convenience for aerial photographers, engineers, and photogrammetrists who desire a small, compact instru-

ment (fits easily, with case, in ordinary vest pocket). Interpupillary adjustment is of new design, requiring only a slight pull to separate lenses to desired working distance. No screws or nuts to become loose. Adjustment is permitted from 55 to 75 mm. Lenses are 4½" focal length, four-power magnification, distortionless type. Leather case is optional. Overall size of case with stereoscope inserted is ½" × 3⅛" × 5½". —*Abrams Instrument Co., 606 E. Shiawassee St., Lansing, Mich.*

Stratosphere Chamber"

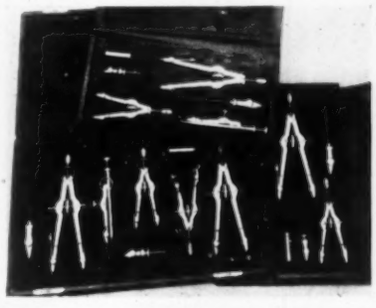
"Stratosphere Chamber" has cylin- cabinet 110" long × 92" diameter machine housing approx. 96" long × ide × 92" high. Interior dimensions net are approx. 72" diam. × 80" long with net usable service space 80" comprising approx. three-fifths of cylin-



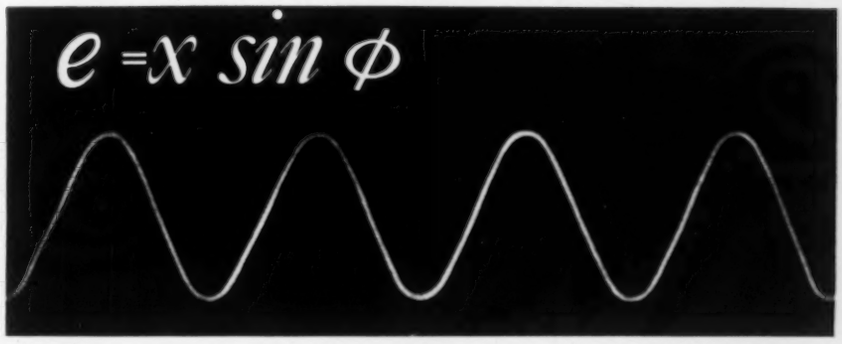
der with center height somewhat greater than 40". Equipment produces the following conditions: (A) Temperatures from 167° F. to −70° F. variable at the rate of 5° F. per minute in the range 167° to 10° and at a diminishing rate down to ½° per minute at −70°. (B) Internal pressure controllable from ambient to 3" mercury absolute at a diminishing rate throughout the pressure drop period (18 minutes or less). Pressure rise controlled by hand-operated air admission valve. Minimum pressure limit attained and maintained automatically; modulation of rate of pressure drop is by manipulation of hand valve. (C) Humidity control from 25% to 95% relative at all temperatures above 40° F. or fixed bottom temperature of 32° F., below which absolute humidity corresponds to the air saturation at the coil temperature which averages 15° to 20° lower than chamber temperature. Introduction of moisture on the temperature rise half of the cycle is from electrically heated vapor generator; semi-automatic, but regulated by valve manipulated by operator. There is a full complement of industrial instruments, safety interlocks, etc.—*Kold Hold Mfg. Co., 124 N. Grand Ave., Lansing, Mich.*

Drawing Instruments

Available in three combinations of bows, drop bows, and pens, a new and complete line of American-made drawing instruments is announced under the trade name "Vemco."



Instruments are said to embody new and unique features of open truss design which increase strength and rigidity while cutting weight by 40%. It is pointed out that this rigidity, combined with absolute concentricity, enables user to describe extra-large dense circles in pencil without instrument yielding. Each bow has a center-screw adjustment which articulates with the legs by cylindrical nuts. The legs bear upon a double-grooved hinge pin of broad base, assuring strength and alignment. Construction is of steel, satin-chrome plated. Sets are available in one-, two-, and three-bow combinations complete with dividers and pens, packed in velvet-lined leather cases.—*V & E Engineering Co., Pasadena, Calif.*



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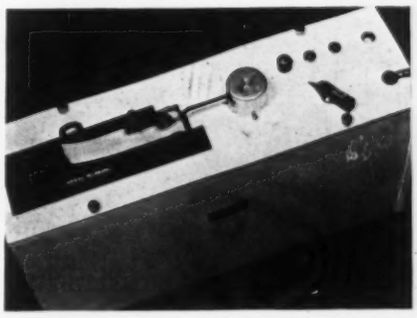

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